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TO THE

PRACTICAL QUESTIONS AND PROBLEMS

CONTAINED IN

THE FOURTEEN WEEKS COURSES

IN

Natural Philosophy, Chemistry, and Astronomy.

BY

J. DORMAN STEELE, A.M., Ph. D.,

PRINCIPAL OF ELMIRA FREE ACADEMY.

Author of "A Fourteen Weeks Course in Philosophy," "A Fourteen Weeks Course in Chemistry," and "A Fourteen Weeks Course in Astronomy."

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PREFACE.

This little work is designed to aid teachers who are using the Fourteen Weeks' Course. The problems contained in all the books are fully, and, it is thought, accurately solved. Great pains have been taken to revise and compare them carefully. The practical questions are answered, often not in full, yet enough so to give the key to the more perfect reply. The use of the text-books is presupposed, and the statements merely supplement, or apply the fuller theories therein contained and explained. On many points there may be a difference of opinion. The author often finds in his own classes a wide diversity. On mooted questions he has merely advanced one view, leaving the subject open for the discussion of other theories. Minute directions are given, at the close of the book, for performing a course of experiments in Chemistry. It is hoped that these may be of service to teachers who, with incomplete apparatus, are trying to illustrate to their pupils some of the principles of that science. In all cases of doubt or misunderstanding with regard to the answers or solutions, the author will be pleased to correspond with any teacher using the Series.

Elmira, March 19, 1870.

ANSWERS

TO THE PRACTICAL QUESTIONS

IN THE

FOURTEEN WEEKS' COURSE

IN

NATURAL PHILOSOPHY.

[The bold-faced figures refer to the pages of the Philosophy; the others to the number of the Practical Questions.]

INERTIA.

26. 1. *If one is riding rapidly, in which direction will he be thrown when the horse is suddenly stopped?*

In the same direction in which he is going. He has the motion of the carriage, and his inertia carries him forward.

2. *When standing in a boat, why, as it starts, are we thrown backward?*

Because the inertia of our bodies keeps them stationary, while the boat carries our feet forward.

3. *When carrying a cup of tea, if we move or stop quickly, why is the liquid liable to spill?*

The inertia of the tea tends to keep it still or in motion, as the case may be. If we move the cup quickly, the motion is not imparted to the liquid soon enough to overcome the inertia. When, therefore, we start, the tea spills out backward; or, when we stop, it spills out forward. We understand this if we can tell why a cup of tea is more liable to spill than one of sugar.

4. *Why, when closely pursued, can we escape by dodging?*

We turn sharply. Our pursuer, ignorant of our design, cannot overcome his inertia so as to turn as quickly, and hence is carried past.

5. *Why is a carriage or sleigh, when sharply turning a corner, liable to tip over?*

Because its inertia tends to carry it directly forward. A puzzling question in this connection is—Why is a sleigh more liable to tip over than a wagon?

6. *Why, if you place a card on your finger, and on top of it a cent, can you snap the card from under the cent without knocking the latter off your finger?*

Because the friction between the card and the cent is so slight that, by a quick snap, you can overcome the inertia of the former without imparting any force to the latter.

7. *Why, after the sails of a vessel are furled, does it still continue to move; and why, after the sails are all spread, does it require some time to get under full headway?*

Its inertia must be overcome in the one case by the resistance of the air and water, and in the other by the force of the wind.

COHESION.

40. 1. *Why can we not weld a piece of copper to one of iron?*

Cohesion acts only between molecules of the same kind.

2. *Why is a bar of iron stronger than one of wood?*

Because its force of cohesion is stronger.

3. *Why is a piece of iron, when perfectly welded, stronger than before it was broken?*

By the hammering, more particles are brought within the range of cohesion.

4. *Why do drops of different liquids vary in size?*

Because they vary in cohesive force.

5. *Why, when you drop medicine, will the last few drops contained in the bottle be of a larger size than the others?*

The pressure of the liquid in the bottle is less, and therefore they form more slowly.

6. *Why are drops larger if you drop them slowly?*

There is more time for the adhesive force of the bottle to act on the liquid, and so a larger drop can be gathered.

7. *Why is a tube stronger than a rod of the same weight?*

Let a rod supported at both ends be broken in the middle. We shall see that it yields first on the circumference. So true is this, that long beams heavily loaded have been broken by a mere scratch of a pin on the lower side. The particles along the centre break last. They rather aid in the fracture, since they afford a fulcrum for the rest of the rod, acting as the long arms of a lever, to act upon. In a tube the particles at the centre are removed and all concentrated at the outside, where the first strain is felt.

8. *Why, if you melt scraps of zinc, will they form a solid mass when cooled?*

The heat overcomes, in part, the attraction of cohesion, so that the particles flow freely on each other. They now all come within the range of cohesion, so that when the metal cools they are held by that force in a solid mass.

9. *In what liquids is the force of cohesion greatest?*

Mercury, molasses, etc.

10. *Name some solids that will volatilize without melting?*

Wood, coal, arsenic, camphor.

ADHESION.

47. 1. *Why does cloth shrink when wet?*

By capillary attraction the water is drawn into the pores of the cloth. The fibres are thus expanded sidewise and shortened lengthwise. The cloth "*fulls up*" or thickens while it shortens and narrows (*shrinks*) in the process.

2. *Why do sailors at a boat-race wet the sails?*

The pores being full and expanded make the sails more compact. They will therefore hold the wind better.

3. *Why does not writing-paper blot?*

Because the pores are filled with size. (See Chemistry, p. 161.)

4. *Why does paint prevent wood from shrinking?*

Because it fills the pores of the wood.

5. *What is the shape of the surface of a glass of water and one of mercury?*

Ordinarily the former is concave and the latter convex.

6. *Why can we not dry a towel perfectly by wringing?*

Because of the strength of the capillary force by which the water is held in the pores of the cloth.

7. *Why will not water run through a fine sieve when the wires have been greased?*

Because the grease repels the water and so prevents capillary action.

8. *Why will camphor dissolve in alcohol and not in water?*

Because there is a strong adhesion between the alcohol and camphor, and little, if any, between the water and camphor.

9. *Why will mercury rise in zinc tubes as water does in glass tubes?*

Because of the strong adhesion between zinc and mercury.

10. *Why is it so difficult to lift a board out of water?*

Because of the adhesion between the board and the water.

11. *Why will ink spilled on the edge of a book extend further inside than if spilled on the side of the leaves?*

Because the capillary pores of the paper are short, being only the thickness of a leaf, while the capillary spaces between the leaves are longer and continuous.

12. *If you should happen to spill some ink on the edge of your book, ought you to press the leaves together?*

No. Because you would make the capillary spaces between the leaves smaller, and so the ink would rise in them further.

13. *Why can you not mix oil and water?*

Because there is no adhesion between them.

15. *Why will water wet your hand while mercury will not?*

Because in the former case there is an adhesion, in the latter none.

16. *Why is a tub or pail liable to fall to pieces if not filled with water or kept in the cellar?*

Because the moisture dries out of the pores, and the wood shrinks so as to let the hoops fall off.

17. *Name instances where the attraction of adhesion is stronger than that of cohesion.*

Wood fastened by glue will often split before the glue will yield. Paper stuck with paste, and bricks with mortar, are also examples.

GRAVITATION.

63. 1. *When an apple falls to the ground, how much does the earth rise to meet it?*

The earth falls as much less distance than the apple, as its weight is greater.

2. *What causes the sawdust in a mill-pond to collect in large masses?*

The attraction of gravity which exists between all bodies, whereby they attract each other. All bodies on the earth would tend to approach each other, and the big ones would gather all the little ones around them were they as free to move as the sawdust floating on water.

3. *Will a body weigh more in a valley than on a mountain?*

It will, because the attraction of the earth is greater.

4. *Will a pound weight fall more slowly than a two-pound weight?*

They will both fall in the same time, except the slight difference which is caused by the resistance of the air. Galileo propounded this view and proved it, in the presence of a vast crowd, by letting unequal weights fall from the leaning tower of Pisa.

5. *How deep is a well, if it takes three seconds for a stone to fall to the bottom of it?*

(2) equation of falling bodies, $d = 16t^2$; hence $d = 16 \times 3^2 = 144$ feet.

6. *Is the centre of gravity always within a body—as, for example, a ring?*

It is not. In the case given it is at the centre of the circle.

7. *If two bodies, weighing respectively 2 and 4 pounds, be connected by a rod 24 inches long, where is the centre of gravity?*

To be in equilibrium the weight of one multiplied by its distance from the centre of gravity must equal the weight of the other multiplied by its distance. $24 \div 6 = 4$; hence 4 in. is the unit for each pound. Therefore the centre of gravity is 8 in. from the larger weight and 16 in. from the smaller.

8. *In a ball of equal density throughout, where is the centre of gravity?*

At the centre of the ball.

9. *Why does a ball roll down hill?*

Because the line of direction falls without the small base of the ball.

10. *Why is it easier to roll a round body than a square one?*

Because the base of the ball is so much smaller, and therefore the centre of gravity need not be raised to bring the line of direction without.

11. *Why is it easier to tip over a load of hay than one of stone?*

Because the centre of gravity in a load of hay is very high, and in a load of stone very low. Therefore the centre of gravity in the former need not be raised much to bring the line of direction without the base, while in the latter it must be.

12. *Why is a pyramid the stablest of structures?*

Because the base is so broad and the centre of gravity so low. The centre of gravity must therefore be lifted very high before the line of direction will fall without the base.

13. *When a hammer is thrown, on which end does it always strike?*

On the heavy end or head, because that part is attracted by the earth more strongly.

14. *Why does a rope-walker carry a heavy balancing-pole?*

Because in this way he can easily shift his centre of gravity.

15. *What would become of a ball if dropped into a hole bored through the centre of the earth?*

In falling, it would gain a momentum which would carry it past the centre of the earth. But as it is constantly coming to a part having a slower axial revolution than itself, it would scrape on the east side of the hole until it reached the centre; beyond that point it would scrape on the west side. This friction would prevent its reaching the opposite side of the earth. It would therefore vibrate to and fro, each time through a shorter distance, until, at last, it would come to rest at the centre of the earth.

16. *Would a clock lose or gain time if carried to the top of a mountain?*

It would lose time, because the force of gravity would be lessened. At the North Pole it would gain time, because there the force of gravity would be increased.

17. *In the winter, would you raise or lower the pendulum-bob of your clock?*

I would lower it, since the cold of winter shortens the pendulum, and this movement of the bob would counteract that change.

18. *Why is the pendulum-bob always made flat?*

To decrease the friction of the air.

19. *What beats off the time in a watch?*

The vibration of the balance-wheel.

20. Is solved in the book.

21. *What should be the length of a pendulum at New York to vibrate half-seconds?*

$$(1\text{ sec.})^2 : (1/2\text{ sec.})^2 :: 39.1\text{ in.} : x = 9.7 + \text{inches.}$$

To vibrate quarter-seconds?

$$(1\text{ sec.})^2 : (1/4\text{ sec.})^2 :: 39.1\text{ in.} : x = 2.4 + \text{inches.}$$

To vibrate hours?

$$(1\text{ sec.})^2 : (3600\text{ sec.})^2 :: 39.1\text{ in.} : x = 7997.7\text{ miles.*}$$

* Nearly the diameter of the earth.

22. *What is the proportionate time of vibration of two pendulums,* 16 *and* 64 *inches long, respectively?*

According to the third law of pendulums,

Time of vib. of 1st : Time of vib. of 2d :: $\sqrt{16}$: $\sqrt{64}$ :: 4 : 8 :: 1 : 2.

23. *Why, when you are standing erect against a wall, and a piece of money is placed between your feet, can you not stoop forward and pick it up?*

By leaning forward you bring the centre of gravity in front of your feet, and, as on account of the wall, you cannot throw any part of your body back to preserve the balance, you fall forward.

24. *If a tower were* 198 *feet high, with what velocity would a stone dropped from the summit, strike the ground?*

According to equation (3), $v^2 = 64\,d$. $v^2 = 64 \times 198$. $v = 112.5$ feet.

25. *A body falls in* 5 *seconds: with what velocity does it strike the ground?*

According to equation (1), $v = 32\,t$. $v = 32 \times 5$. $v = 160$ feet.

26. *How far will a body fall in* 10 *seconds?*

According to equation (2), $d = 16\,t^2$. $d = 16 \times 10^2 = 1600$ feet.

With what velocity will it strike the ground?

According to equation (1), $v = 32\,t$. $v = 32 \times 10 = 320$ feet.

27. *A body is thrown upward with a velocity of* 192 *feet the first second; to what height will it rise?*

Equation (1), $v = 32\,t$. $192 = 32\,t$. $t = 6$ sec.
" (2), $d = 16\,t^2$. $d = 16 \times 6^2 = 576$ feet.

28. *A ball is shot upward with a velocity of* 256 *feet; to what height will it rise? How long will it continue to ascend?*

Using equations (1) and (2), as in the last problem, we have:

$t = 8$ sec.

$d = 1024$ feet.

30. *Are any two plumb-lines parallel?*

They are not, since they all point to the centre of the earth. No two spokes of a wheel can be parallel.

31. *A stone let fall from a bridge strikes the water in three seconds. What is the height?*

Equation (2), $d = 16t^2$. $d = 16 \times 3^2 = 141$ feet.

32. *A stone falls from a church steeple in 4 seconds. What is the height?*

Equation (2), $d = 16t^2$. $d = 16 \times 4^2 = 256$ feet.

33. *How far would a body fall the first second at a height of 12,000 miles above the earth's surface?*

$(16{,}000 \text{ mi.})^2 : (4000 \text{ mi.})^2 :: 16 \text{ feet} : x = 1$ foot.

34. *A body at the surface of the earth weighs 100 tons: what would be its weight 1,000 miles above.*

$(5000 \text{ mi.})^2 : (4000 \text{ mi.})^2 :: 100 \text{ tons} : x = 64$ tons.

35. *A boy wishing to find the height of a steeple lets fly an arrow that just reaches the top and then falls to the ground. It is in the air 6 seconds. Required the height.*

Equation (2), $d = 16\,t^2$. $d = 16 \times 3^2 = 144$ ft.

36. *A cat let fall from a balloon reaches the ground in 10 seconds. Required the distance.*

Equation (2), $d = 16 \times 10^2 = 1600$ ft.

37. *In what time will a pendulum 40 feet long make a vibration?*

According to the third law of pendulums, and taking the length of a seconds' pendulum as 39 in., we have:

$$1 \text{ sec.} : x :: \sqrt{39} : \sqrt{40 \times 12 \text{ in.}}$$

$$x = \sqrt{\frac{480}{39}} = 12.30+$$

$$x = 3.5+ \text{ sec.}$$

—*In what time will a pendulum 52 feet long make a vibration?*

$$1 \text{ sec.} : x :: \sqrt{39} \text{ in.} : \sqrt{52 \times 12 \text{ in.}}$$

$$x = \sqrt{\frac{624}{39}} = 4 \text{ sec.}$$

—How long would it take for a pendulum one mile in length to make a vibration?

—How long would it take for a pendulum reaching from the earth to the moon to make a vibration?

—Required the length of a pendulum that would vibrate centuries. (To be solved like problem 20.)

38. *Two meteoric bodies in space are 12 miles apart. They weigh 100 and 200 lbs. respectively. If they should fall together by force of their mutual attraction, what portion of the distance would be passed over by each body?*

The distance passed over by the two bodies is inversely as their mass; hence one moves 8 miles and the other 4 miles.

39. *If a body weighs 2,000 lbs. upon the surface of the earth, what would it weigh 2,000 miles above?*

$$(6000 \text{ mi.})^2 : (4000 \text{ mi.})^2 :: 2000 \text{ lbs.} : x = 888^8/_9 \text{ lbs.}$$

—How much 500 miles above?

$$(4500 \text{ mi.})^2 : (4000 \text{ mi.})^2 :: 2000 \text{ lbs.} : x = 1580 + \text{lbs.}$$

The weight of bodies below the surface of the earth decreases as the distance increases. *Ex.: What would the above body weigh if carried 2,000 miles below the surface?* 1,000 lbs. —1,000 *miles below?* 1,500 lbs.

40. *At what distance above the surface of the earth will a body fall, the first second, 21⅓ inches?*

A body falls 16 ft.* (192 inches) at the surface of the earth. $21^1/_3$ inches are $^1/_9$ of 192 inches: Now as the attraction is inversely as the square of the distance, the distance must be $\sqrt{9}$, or 3 times that at the surface. Hence the body must be 12,000 miles from the centre, or 8,000 miles from the surface of the earth. The problem may be solved directly by proportion, thus:

$$x^2 : 4000^2 :: 192 \text{ inches} : 21^1/_3 \text{ inches.}$$

$$x = 12000 \text{ miles (distance from the centre)}$$

$$12000 \text{ miles} - 4000 \text{ miles} = 8000 \text{ miles.}$$

41. *How far will a body fall in 8 seconds?* 1,024 ft.—*In the 8th second?* 240 ft.—*In 10 seconds?* 1,600 ft.—*In the 30th second?* 944 ft.

* According to the best authorities the distance is more exactly $16^1/_{12}$ ft.

MOTION.

80. 1. *Can a rifle-ball be fired through a handkerchief suspended loosely from one corner?*

No. The wind of the ball will lift the handkerchief.

2. *A rifle-ball* thrown *against a board standing edgewise will knock it down; the same bullet* fired *at the board will pass through it without disturbing its position. Why is this?*

The ball which is thrown has time to impart its motion to the board; the one fired has not.

3. *Why can a boy skate safely over a piece of thin ice, when, if he should pause, it would break under him directly?*

In the former case there is time for the weight of his body to be communicated to the ice; in the latter, there is not.

4. *Why can a cannon-ball be fired through a door standing ajar, without moving it on its hinges?*

Because the cannon-ball is moving so quickly that its motion is not imparted to the door.

5. *Why can we drive on the head of a hammer by simply striking the end of the handle?*

This can only be done by a quick, sharp blow which will drive the wooden handle through the socket before the motion has time to overcome the inertia of the iron head. A slow, steady blow will be imparted to the head, and so fail of the desired effect.

6. *Suppose you were on a train of cars moving at the rate of* 30 *miles per hour: with what force would you be thrown forward if the train were stopped instantly?*

With the same velocity which the train had, or 44 feet per second. Your momentum would be your weight avoirdupois multiplied by this velocity.

7. *In what line does a stone fall from the mast-head of a vessel in motion?*

In a curved line, produced by the two forces—gravity and the forward motion of the vessel.

8. *If a ball be dropped from a high tower it will strike the earth a little east of a vertical line. Why is this?*

In the daily revolution of the earth on its axis, from west to east, the top of the tower moves faster than the bottom, because it passes through a larger circle. When, therefore, the ball falls, it retains that swifter easterly motion and so strikes east of the vertical.

9. *It is stated that a suit was once brought by the driver of a light-wagon against the owner of a coach for damages caused by a collision. The complaint was that the latter was driving so fast, that when the two carriages struck, the driver of the former was thrown forward over the dash-board. Show how his own testimony proved him to have been at fault.*

When the light-wagon was suddenly stopped, its driver went on by his inertia with the same speed at which the wagon was moving. That this threw him forward over the dash-board, proves his speed to have been unusual.

10. *Suppose a train moving at the rate of* 30 *miles per hour; on the rear platform is a cannon aimed parallel with the track and in a direction precisely opposite to the motion of the car. Let a ball be discharged with the exact speed of the train, where would it fall?*

In a vertical line to the track. The two equal, opposite motions would exactly destroy each other.

11. *Suppose a steamer in rapid motion and on its deck a man jumping. Can he jump further by leaping the way the boat is moving or in the opposite direction?*

It will make no difference as long as he jumps on the deck. Should he jump off the boat, then the effect would be different.

12. *Why is a running jump longer than a standing one?*

Because the motion gained in running is retained in the jump and adds to its distance.

13. *If a stone be dropped from the mast-head of a vessel in motion, will it strike the same spot on the deck that it would if the vessel were at rest?*

It will. It falls with the motion of the vessel, and goes just as far forward while falling as the vessel does.

14. *Could a party play ball on the deck of the Great Eastern when steaming along at the rate of 20 miles per hour, without making allowance for the motion of the ship?*

They could. The ball would have the motion of the ship, and would move with it in whatever direction they might throw it.

15. *Since "action is equal to reaction," why is it not as dangerous to receive the "kick" of a gun as the force of the bullet?*

The striking force is as the square of the velocity; and the velocity with which the gun moves backward is as much less than that with which the bullet moves forward, as the gun is heavier than the bullet. For this reason a heavy gun will kick much less than a light one.

16. *If you were to jump from a carriage in rapid motion, would you leap directly toward the spot on which you wished to alight?*

No; because as one jumps from the wagon he has its forward motion, and will go just as far ahead, while leaping, as he would if he had remained in the carriage. He should, therefore, aim a little back of the desired alighting-place.

17. *If you wished to shoot a bird in swift flight, would you aim directly at it?*

No. The bird will fly forward while the bullet is going to it. One should, therefore, aim a little in advance.

18. *At what parts of the earth is the centrifugal force the least?*

The poles. They simply turn around in 24 hours.

19. *What causes the mud to fly from the wheels of a carriage in rapid motion?*

The centrifugal force.

20. *What proof have we that the earth was once a soft mass?*

It is flattened at the poles. This effect is produced upon a ball of soft clay by simply revolving it on a wire axis.

21. *On a curve in a railroad, why is one track always higher than the other?*

The outer track is raised that gravity may balance the centrifugal force.

22. *What is the principle of the sling?*

The sling is whirled until a strong centrifugal force is generated; the string, the centripetal force, is then released, when the stone flies off at a tangent.

23. *The mouth of the Mississippi river is about 2½ miles further from the centre of the earth than its source. What causes its water to thus "run up hill?"*

The centrifugal force produced by the revolution of the earth on its axis tends to drive the water from the poles toward the equator. Were the earth to stand still in its daily rotation, the Gulf of Mexico would empty its waters back through the Mississippi to the northern regions.

24. *Is it action or reaction that breaks an egg when I strike it against the table?*

The reaction of the table.

25. *Was the man philosophical who said "it was not the falling so far but the stopping so quick that hurt him?"*

He was.

26. *If one person runs against another, which receives the greater blow?*

Action is equal to reaction: hence the blows must be equal.

27. *Would it vary the effect if the two persons were running in opposite directions?*

The blow would then be the *sum* of both their momenta.

If they were running in the same direction?

The blow would be equal to the *difference* of their momenta.

28. *Why can you not fire a rifle-ball around a hill?*

Because a single force always produces motion in a straight line.

29. *Why does a heavy gun "kick" less than a light one?*

See problem 15.

30. *A man on the deck of a large steamer draws a small*

boat toward him. How much does the ship move to meet the boat?

The ship moves as much less distance than the boat, as it is heavier than the boat.

31. *Suppose a string, fastened at one end, will just support a weight of* 25 *lbs. at the other. Unfasten it, and let two persons pull upon it in opposite directions. How much can each pull without breaking it?*

25 lbs. The second person, in the latter case, can pull as much as the nail did in the former.

32. *Can a man standing on a platform-scale make himself lighter by lifting up on himself?*

He cannot; because action is equal to reaction, and in an opposite direction. As much as he lifts up, so much must he press down.

33. *Why cannot a man lift himself by pulling up on his boot-straps?*

See last problem.

34. *If from a gun placed vertically, a ball were fired into perfectly still air, where would it fall?*

It would return into the gun.

35. *With what momentum would a steamboat weighing* 1,000 *tons, and moving with a velocity of* 10 *feet per second, strike against a sunken rock?*

$$1000 \text{ tons} \times 10^2 = 100{,}000 \text{ tons.}$$

36. *With what momentum would a train of cars weighing* 100 *tons, and running* 10 *miles per hour, strike against an obstacle?*

The velocity per second is $14^2/_3$ ft. 100 tons $\times (14^2/_3)^2 = 21{,}511^1/_9$ tons.

37. *What would be the comparative striking-force of two hammers, one driven with a velocity of* 20 *feet per second, and the other* 10 *feet?*

$20^2 = 400$. $10^2 = 100$. $400 : 100 :: 1 : 4$. Hence one will strike four times as hard a blow as the other. This principle is of great importance in chopping wood, splitting rails, and in all cases where percussion is concerned. The highest attainable velocity is to be sought.

—*There is a story told of a man who erected a huge pair of bellows in the stern of his pleasure-boat, that he might always have a fair wind. On trial the plan failed. In which direction should he have turned the bellows?*

In the manner adopted at first, of turning the nozzle toward the sails, the action of the wind against the sails and the reaction of the bellows against the boat just balanced each other. If the man had turned the nozzle backward he could have saved the reaction of the bellows to move the boat. This would, however, have been a most costly and bungling way of navigation.

—*If we whirl a pail of water swiftly around with our hand, why will the water all tend to leave the centre of the pail? Why will the foam all collect in the hollow at the centre?*

THE MECHANICAL POWERS.

99. 1. *Describe the rudder of a boat as a lever.*

The water is the F, the boat the W, and the hand the P. As the W is between the F and the P, it is a lever of the second class.

2. *Show the change that occurs from the second to the third class of levers, when you take hold of a ladder at one end and raise it against a building.*

At first the ground is the F at one end, the hand the P at the other, and the ladder the W hanging between; hence this is a lever of the second class. After a little, the F remaining the same, the P is applied at one end, near the F, and the ladder is the W hanging at the other; hence this is now a lever of the third class.

3. *Why is a pinch from the tongs near the hinge more severe than one near the end?*

Because in the former case the tongs are a lever of the first class—in the latter, of the third. In the first class there is a gain of power, in the third a loss.

4. *Two persons are carrying a weight of 250 lbs., hanging*

between them from a pole 10 *feet in length. Where should it be suspended so that one will lift only* 50 *lbs.?*

One lifts 50 lbs.; the other 200 lbs. The proportionate length of the arms of the lever should be the same as the proportionate weights—*i. e.*, 1 to 4. 10 ÷ 5 = 2, the unit of measure. Hence one arm is 2 feet long and the other 8 feet long. PROOF.—(See Prob. 7, p. 10.) 50 × 8 = 200 × 2. This is the substance also of the equation P × P*d* = W × W*d*.

5. *In a lever of the first class,* 6 *feet long, where should the F be placed so that a P of* 1 *lb. will balance a W of* 23 *lbs.?*

6 feet = 72 inches. 72 ÷ 24 = 3, the unit of distance. The W must be placed 3 in. and the P 69 in. from the F. PROOF. 23 × 3 = 1 × 69 (Prob. 4).

6. *What P would be required to lift a barrel of pork with a windlass whose axle is one foot in diameter and handle* 3 *ft. long?*

$$P : W : \text{rad. of axle} :: \text{rad. of wheel.}$$

$$x : 200 \text{ lbs} :: {}^1/_2 \text{ ft.} : 3 \text{ ft.}$$

$$x = 33^1/_3 \text{ lbs.}$$

7. *What sized axle, with a wheel* 6 *feet in diameter, would be required to balance a W of* 1 *ton by a P of* 100 *lbs.?*

$$P : W :: \text{rad. of axle} : \text{rad. of wheel.}$$

$$100 \text{ lbs.} : 2000 \text{ lbs.} :: x : 3 \text{ ft.}$$

$$x = {}^3/_{20} \text{ ft.} = \text{the rad.; hence the diameter} = {}^3/_{10} \text{ ft.}$$

8. *What number of movable pulleys would be required to lift a W of* 200 *lbs. with a P of* 25 *lbs.?*

$$W = P \times \text{twice the no. of mov. pulleys; hence } \frac{W}{P} = \text{twice the no. of mov. pul's.}$$

$$200 \div 25 = 8. \quad 8 \div 2 = 4 = \text{the no. required.}$$

9. *How many lbs. could be lifted with a system of* 4 *movable pulleys, and one fixed pulley to change the direction of the force, by a P of* 100 *lbs.?*

$$W = P \times \text{twice the no. of mov. pulleys.}$$

$$100 \text{ lbs.} \times (4 \times 2) = 800 \text{ lbs.} = \text{the W.}$$

10. *What weight could be lifted with a single horse-power (*33,000 *lbs.) acting on the tackle-block?* (Fig. 62.)

This block has 3 movable pulleys, and using the equation of the pulleys given in the last two problems, we have, making no allowance for friction,

$$33{,}000 \text{ lbs.} \times (3 \times 2) = 198{,}000 \text{ lbs.}$$

11. *What distance could there be between the threads of a screw, that a P of 25 lbs., acting on a handle 3 ft. long, may lift 1 ton weight?*

P : W :: Interval : Circumference.

25 lbs. : 2000 lbs. :: x : 72 in. × 3.1416.

$x = 2.83 -$ in.

12. *How high could a P of 12 lbs., moving 16 ft. along an inclined plane, lift a W of 96 lbs.?*

P : W :: height : length.

12 lbs : 96 lbs. : : x : 16 ft.

$x = 2$ ft.

13. *I wish to roll a barrel of flour into a wagon, the box of which is 4 ft. from the ground. I can lift but 24 lbs. How long a plank should I get?*

P : W :: height : length.

24 lbs : 196 lbs. :: 4 ft. : $x = 32^2/_3$ ft.

14. *The "evener" of a pair of whiffletrees is 3 ft. 6 in. long; how much must the whiffletree be moved to give one horse the advantage of ⅓ over the other?*

For every 3 lbs. one horse pulls, the other must pull 4 lbs.: hence 7 represents the proportion in which the load is to be divided. 3 ft. 6 in. = 42 inches. 42 in. ÷ 7 = 6 inches, the unit of measure. Hence one arm of the evener must be 6 in. × 3 = 18 in. long, and the other 6 in. × 4 = 24 in. long. Or, if we prefer, we may say 21 in. — 3 in. = 18 in. long, and 21 in. + 3 in. = 24 in. long. PROOF.—(See Prob. 4, p. 20.) 18 × 4 = 24 × 3 = 72.

15. *In a set of three horse whiffletrees, having an "evener" 5 ft. long, at what point should the plough-clevis be attached that the single horse may draw the same as each one of the span of horses?*

For every lb. drawn by the single horse the span should draw 2 lbs.: hence 3 represents the proportion in which the load is to be divided. 60 in. ÷ 3 = 20 in., the unit of measure. 20 in. × 1 = 20 in., and 20 in. × 2 = 40 in. Hence one arm must be 20 in., and the other 40 in. long.

To give ¼ advantage?

The single horse should draw 3 lbs. and each of the others 4 lbs.: hence the span should draw 8 lbs. 60 in. ÷ 11 = $5^5/_{11}$ in., the unit of measure. $5^5/_{11}$ in. × 3 = $16^4/_{11}$ in., and $5^5/_{11}$ in. × 8 = $43^7/_{11}$ in.

16. *What W can be lifted with a P of 100 lbs. acting on a screw having threads ¼ of an inch apart and a lever handle 4 ft. long?*

P : W :: Interval : Circumference.

100 lbs. : x :: $^1/_4$ in. : 96 in. × 3.1416.

x = 120,637 + lbs.

17. *What is the object of the big balls cast on the ends of the handle of the screw used in copying-presses?*

By their inertia and centrifugal force they make the motion more uniform and continuous.

18. *In a steelyard 2 ft. long, the distance from the weight-hook to the fulcrum-hook is 2 in. How heavy a body can be weighed with a 1 lb. weight at the further end?*

24 in. — 2 in. = 22 in. 1 lb. × 22 = 22 lbs. = P. 22 lbs. ÷ 2 = 11 lbs. = W.

19. *Describe the change from the 1st to the 3d class of levers, in the different ways of using a spade.*

When digging, the ground at the back of the spade is the F; the ground lifted is the W; and the hand at the other end is the P. As the W is at one end, P at the other, and the F between, this is a lever of the 1st class. When throwing dirt, the left hand at one end of the spade is the F; the dirt at the other end is the W, and the right hand between the two is the P. As the P is between the F and the W, this is a lever of the 3d class.

20. *Why are not blacksmiths' and fire tongs constructed on the same principle?*

The former are of the 1st class, as power is required: the latter of the 3d class, as rapidity only is necessary.

21. *In a lever of the 3d class, what W will a P of 50 lbs. balance, if one arm is 12 ft. and the other 3 ft. long?*

P : W :: Wd : Pd.

50 lbs. : x :: 12 ft. : 3 ft.

x = $12^1/_2$ lbs.

22. *In a lever of the 2d class, what W will a P of 50 lbs. balance, with a lever 12 feet long and W 3 feet from the F?*

50 lbs. : x :: 3 ft. : 12 ft.

x = 200 lbs.

23. *In a lever of the* 1st *class, what W will a P of* 50 *lbs. balance. with a lever* 12 *ft. long and the F* 3 *ft. from the W?*

$$50 \text{ lbs.} : x :: 3 \text{ ft.} : 9 \text{ ft.}$$

$$x = 150 \text{ lbs.}$$

24. *In a wheel and axle, the P* = 40 *lbs., W* = 360 *lbs., diameter of axle* = 8 *in. Required the circumference of the wheel.*

P : W :: diameter of axle : diam. of wheel

40 lbs. : 360 lbs. :: 8 in. : x = 72 in. = 6 ft., the diameter of wheel.

6 ft. × 3.1416 = 18.85 ft., the circumference of the wheel.

25. *In a wheel and axle the P* = 20 *lbs., the W* = 240 *lbs., and the diameter of wheel* = 4 *ft. Required the circumference of the axle.*

20 lbs : 240 lbs :: x : 48 in.

x = 4 in. (diameter of axle).

4 in. × 3.1416 = 12.56 in. (circumference).

26. *Required, in a wheel and axle, the diameter of the wheel, the diameter of the axle being* 10 *inches, P* = 100 *lbs. and W* = 1 *ton.*

100 lbs. : 2000 lbs. :: 10 in. : x = 200 in. = $16^2/_3$ ft.

27. *What P would be necessary to sustain a weight of* 3,780 *lbs., with a system of* 6 *movable pulleys and one rope?*

W = P × twice the no. of mov. pulleys.

3,780 lbs. = P × (6 × 2). P = 315 lbs.

28. *How many movable pulleys would be required to sustain a W of* 420 *lbs. with a P of* 210 *lbs.?*—Ans. 1.

HYDROSTATICS.

121. 1. *Why do housekeepers test the strength of lye, by trying whether or not an egg will float on it?*

The potash dissolved in the water to form lye increases the density of the liquid. When enough has been dissolved to make its specific gravity greater than that of the egg, the egg will float. This becomes, therefore, a simple means of testing the amount of potash contained in the lye.

2. *How much water will it take to make a gallon of strong brine?*

A gallon. The salt does not increase the bulk of the liquid.

3. *Why can a fat man swim easier than a lean one?*

Because muscles and bones are heavier than fat. The specific gravity of a fat man is therefore less than that of a lean one.

4. *Why does the firing of a cannon over the water sometimes bring to the surface the body of a drowned person?*

One answer is given in the Philosophy. It is probable, also, that the firing of the gun produces a partial vacuum, or in some way takes off, for an instant, a part of the pressure of the air on the water. The gases in the body would then expand and bring it to the top.

6. *If we let bubbles of air pass up through a jar of water, why will they become larger as they ascend?*

The pressure of the water is less as they near the top, and so they expand.

7. *What is the pressure on a lock-gate* 14 *feet high and* 10 *feet wide, when the lock is full of water?*

$$14 \times 10 \times 7 \times 1000 \text{ oz.} = 980{,}000 \text{ oz.} = 61{,}250 \text{ lbs.}$$

8. *Will a pail of water weigh any more with a live fish in it than without?*

If the pail were full before the fish was put in, then it will make no difference, since the fish will displace its own weight of water, which will run over. If the pail is only partially filled, then, though the fish is upheld by the buoyancy of the water, since action is equal to reaction, it adds its own weight to that of the water.

—*If a man and a boy were riding in a wagon, and, on coming to the foot of a hill, the man should take up the boy in his arms, would not that help the horse?*

9. *If the water filtering down through a rock should collect in a crevice an inch square and* 250 *feet high, opening at the bottom into a closed fissure having* 20 *square feet of surface, what would be the total pressure tending to break the rock?*

The pressure is proportional to the height and not the size of the column, hence the pressure is

$$20 \times 250 \times 1000 \text{ oz.} = 5{,}000{,}000 \text{ oz.} = 312{,}500 \text{ lbs.}$$

10. *Why can stones in water be moved so much more easily than on land?*

Because the water buoys up about one-half of their weight.

11. *Why is it so difficult to wade in the water where there is any current?*

Because the buoyant force of the water makes us so light that we are easily carried away from our footing.

12. *Why is a mill-dam or a canal embankment small at the top and large at the bottom?*

Because the pressure of the water increases with the depth.

13. *In digging canals and building railroads, ought not the engineer to take into consideration the curvature of the earth?*

Certainly. If he should build on a true level he would find his embankment pointing up to the stars.

14. *Is the water at the bottom of the ocean denser than that at the surface?*

The immense pressure must condense it very much at great depths. There is a certain point beyond which divers cannot penetrate.

15. *Why does the bubble of air in a spirit-level move as the instrument is turned?*

Because the air is lighter than the alcohol and rises constantly to the highest point. For this reason, also, the tube is curved upward at the centre.

16. *Why can a swimmer tread on glass and other sharp substances at the bottom of the water without harm?*

See problem 11.

17. *Will a vessel draw more water in salt or in fresh water?*

In fresh, because its specific gravity is less.

18. *Will iron sink in mercury?*

No. It will float, like a cork on water.

19. *The water in the reservoir in New York is about 80 feet*

above the fountain in the City Hall Park. What is the pressure on a single inch of the pipe at the latter point?

(1000 oz. × 80) ÷ 144 = 34.7 lbs.

20. *Why does cream rise on milk?*

Because it is lighter than the milk.

21. *If a ship founders at sea, to what depth will it sink?*

Until its specific gravity becomes equal to that of the water?

22. *There is a story told of a Chinese boy who accidentally dropped his ball into a deep hole, where he could not reach it. He filled the hole with water, but the ball would not quite float. He finally bethought himself of a lucky expedient, which was successful. Can you guess it?*

He put salt in the water.

23. *Which has the greater buoyant force, oil or water?*

Water, because its density is greater.

24. *What is the weight of 4 cu. ft. of cork?*

1000 oz. = the weight of 1 cu. ft. of water.
.240 = the spec. grav. of cork.
240 oz. = the weight of 1 cu. ft. of cork.
4
960 oz. = " " 4 " "
= 60 lbs.

25. *How many oz. of iron will a cubic foot of cork float in water?*

1000 oz. = weight of a cubic foot of water.
.240 = spec. grav. of cork.
240 = weight of a cubic foot of cork.
1000 oz. — 240 oz. = 760 oz., the buoyant force of a cubic foot.

26. *What is the specific gravity of a body whose weight in air is 30 grs. and in water 20 grs.?*

30 grs. — 20 grs. = 10 grs.

30 grs. ÷ 10 grs. = 3.

The body is three times as heavy as water.

27. *Which is heavier, a pail of fresh water or one of salt-water?*

A pail of salt-water is as much heavier than one of fresh-water as the weight of the salt added to make the brine.

28. *The weights of a piece of syenite-rock in air and in water were* 3941.8 *grs. and* 2607.5 *grs. Find its spec. grav.* —Ans. 2.954.

29. *A specimen of green sapphire from Siam weighed in air* 21.45 *grs., and in water* 16.33 *grs. Required its spec. grav.*—Ans. 4.189.

30. *A specimen of granite weighs in air* 534.8 *grs., and in water* 334.6 *grs. What is the spec. grav.?*—Ans. 2.671.

31. *What is the bulk of a ton of iron?*

1000 oz. = weight of 1 cu. ft. of water.
7.8 = spec. grav. of iron.

7800 oz. = weight of a cu. ft. of iron.
32,000 oz. (a ton of iron) ÷ 7,800 (weight of a cu. ft.) = $4\,^4/_{39}$ cu. ft.

A ton of gold?

1,000 oz. = weight of a cu. ft. of water.
19.34 = spec. grav. of gold.

19,340 oz.* = weight of a cu. ft. of gold.
32,000 oz.* ÷ 19,340 oz. = 1.6, the no. of cu. ft.

A ton of copper?

1000 oz. × 8.9 = 8900 oz.
32,000 oz. ÷ 8900 oz. = 3.6 (nearly) the no. of cu. ft.

32. *What is the weight of a cube of gold* 4 *feet on each side?*

4^3 = 64, the no. of cu. ft.
19,340 oz.* (no. of oz. in 1 cu. ft.) × 64 = 77,360 lbs.

33. *A cistern is* 12 *ft. long,* 6 *ft. wide, and* 10 *ft. deep. When full of water, what is the pressure on each side?*

On one side, 12 × 10 × 5 × 1000 oz. = 600,000 oz. = 37,500 lbs.
On one end, 6 × 10 × 5 × 1000 oz. = 300,000 oz. = 18.750 lbs.

34. *Why does a dead fish always float on its back?*

It has its swimming-bladder located just under the spine; and this is the lightest part of its body, and, of course, comes to the top as soon as the fish dies.

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* In these solutions the student should notice that avoirdupois weight is used in weighing the gold. To be exact, 1,000 oz., the weight of a cu. ft. of water, should be reduced to Troy weight, and the lb. gold taken as 12 oz. Troy, when the ans. would be about 1.86 cu. ft.

36. *A vessel holds* 10 *lbs. of water: how much mercury would it contain?*

Mercury is 13.5 times heavier than water. Hence the vessel would contain 10 lbs. × 13.5 = 135 lbs. of mercury.

37. *A stone weighs* 70 *lbs. in air and* 50 *in water. What is its bulk?*

70 — 50 = 20. 20 × 16 oz. = 320 oz., the weight of water displaced.

320 oz. is $^8/_{25}$ of a cu. ft.

38. *A hollow ball of iron weighs* 10 *lbs.: what must be its bulk, to float in water?*

10 lbs. = 160 oz. As a cubic ft. of water weighs 1,000 oz., the ball must displace such a part of a cu. ft. of water as 1,000 oz. is contained times in 160 oz., which is .16 cu. ft.

HYDRAULICS.

I. 1. *How much more water can be drawn from a faucet* 8 *feet, than from one* 4 *feet below the surface of the water in a cistern?*

$v = 2\sqrt{gd}$; hence $v = 2\sqrt{16 \times 8} = 22.6$.

$v = 2\sqrt{16 \times 4} = 16$.

Hence 6.6 cu. ft. more would flow from one than from the other in each second.

2. *How much water would be discharged per second from a short pipe having a diameter of* 4 *inches and a depth of* 48 *feet below the surface of the water?*

$4^2 = 16$. $16 \times .7854 = 12.57$ sq. inches = .087 sq. ft. (area of the tube).

$v = 2\sqrt{gd} = 2\sqrt{16 \times 48} = 55.4$

$.087 \times 55.4 = 4.8$ cu. ft.

3. *When we pour molasses from a jug, why is the stream so much larger near the nozzle than at some distance from it?*

Because, according to the law of falling bodies, the further the molasses falls the faster it falls. The stream, therefore, becomes smaller as it moves more swiftly, until, at last, it breaks up into drops.

4. *Ought a faucet to extend into a barrel beyond the staves?*

No; because cross currents would be produced, which would interfere with the free passage of the liquid.

5. *What would be the effect if both the openings in one of the arms in Barker's Mill were on the same side?*

It would cease revolving. The pressure in each direction would then be equal, and the arms would balance.

PNEUMATICS.

148. 1. *Why must we make two openings in a barrel of cider when we tap it?*

One to let out the cider, and one to admit the air.

2. *What is the weight of* 10 *cubic feet of air?*

100 cu. in. weighs 31 grs.; hence 10 cu. ft. will weigh 31 grs. × 172.8 = .7652 lbs. avoirdupois.

3. *What is the pressure of the air on one square rod of land?*

$272\frac{1}{4} \times 144 \times 15$ lbs. = 588,060 lbs.

4. *What is the pressure on a pair of Magdeburg hemispheres* 4 *in. in diameter?*

$3.1416 \times 4^2 \times 15$ lbs. = 753.9 lbs. on each hemisphere.

5. *How high a column of water can the air sustain when the barometric column stands at* 28 *in.?*

28 in. × $13\frac{1}{2} = 31\frac{1}{2}$ feet.

6. *If we should add a pressure of two atmospheres, what would be the bulk of* 100 *cu. in. of common air?*

The pressure is trebled, and according to Mariotte's law, the volume will be reduced in the same proportion; hence it will be 100 cu. in. ÷ 3 = $33\frac{1}{3}$ cu. in.

7. *If, while the water is running through the siphon, we quickly lift the long arm, what will be the effect on the water in the siphon?*

It will all run back through the short arm into the vessel.

8. *If we lift the entire siphon?*

The water will all run out the long arm. The reason of this difference is, that when we lift the long arm we make it in effect the short arm, and the other arm the long one.

8. *When the mercury stands at 29½ in. in the barometer, how high above the surface of the water can we place the lower pump-valve?*

In theory, 29½ in. × 13½ = 398¼ in.; in practice, the distance is much less than this.

9. *Why cannot we raise water, by means of a siphon, to a higher level?*

There is no power in a siphon; it is only a way of guiding the flow of water to a lower level.

10. *If the air in the chamber of a fire-engine be condensed to $\frac{1}{16}$ its former bulk, what will be the pressure due to the expansive force of the air on every square inch?*—Ans. 240 lbs.

11. *What causes the bubbles to rise to the surface, when we put a lump of loaf-sugar in hot tea?*

The bubbles of air contained in the pores of the sugar rise because they are lighter than the water.

12. *To what height can a balloon ascend?*

Until its specific gravity is the same as that of the air in which it floats.

—*What weight can it lift?*

A weight equal to the difference between its own weight and that of the air it displaces.

13. *Why is the air lighter in foul and heavier in fair weather?*

This question is answered in the Philosophy. Another reason may be, that the upward currents of air partly remove the pressure in foul weather.

14. *When smoke ascends in a straight line, is it a proof of the rarity or density of the air?*

Of its density, because it shows that the smoke is much heavier than the air, and so rises immediately to the top.

15. *Why do we not feel the heavy pressure of the air on our bodies?*

Because it is equally distributed within and without our bodies. The pressure on a person of ordinary size is about 16 tons.

16. *Is a bottle empty when filled with air?*

No; because we must empty the air out before we can fill the bottle with anything else.

18. *How does the variation in the pressure of the air affect those who ascend lofty mountains?*

The outward pressure is there partly removed, and the inner pressure remaining the same, the blood is often forced through the ears, nostrils, etc. When one descends into a deep mine the conditions are reversed: the outer pressure becomes in excess of the inner; severe pain is felt in the eardrum, and ringing noises in the head become almost intolerable. These, however, disappear after a time, where the equilibrium between the internal and external pressure is restored. It is said that Humboldt ascended where the mercurial column fell to 14 inches, and descended in a diving-bell where it rose to 45 inches—thus making a variation of 31 inches, or a difference of 31,000 lbs. pressure on his body.

—*If the atmosphere in a diving-bell were of the same density as that at the surface of the earth, how deep in the water would it be necessary to sink the bell in order to reduce the volume of the air one-half, or, in other words, for the bell to half fill with water?*—Ans. 34 feet.

How near would the bell be filled at a depth of 1,020 *feet.*—Ans. $^{29}/_{30}$.

If the bell were then raised, would the water stay in till it reached the surface?

The elasticity of the air would cause it to gradually expand and drive out the water as it rose.

ACOUSTICS.

184. 1. *Why cannot the rear of a long column of soldiers keep time to the music?*

Because it takes time for the sound-wave to pass down the column, and hence those in the rear do not hear the music as soon as those in front.

2. *Three minutes elapse between the flash and the report of a thunderbolt: how far distant is it?*

If the air is at the freezing point, the distance is

$$1090 \text{ ft.} \times 60 \times 3 = 196,200 \text{ ft.}$$

3. *Five seconds expire between the flash and report of a gun: what is the distance?*

$$1090 \text{ ft.} \times 5 = 5450 \text{ ft}$$

4. *Suppose a speaking-tube should connect two villages* 10 *miles apart. How long would it take a sound to pass that distance?*

$$52,800 \text{ ft.} \div 1090 \text{ ft.} = 48.4 \text{ (sec.)}$$

5. *The report of a pistol-shot was returned to the ear from the face of a cliff in* 4 *seconds. How far was it?*

$$1090 \text{ ft.} \times 2 = 2180 \text{ ft.}$$

6. *What is the cause of the difference in the voice of man and woman?*

It may be a difference in the length of the vocal chords, or in the power of lengthening and shortening them; but it is not yet fully understood. The difference between a bass and tenor, as between a contralto and soprano voice, is probably that of quality only, like that between different kinds of musical instruments.

7. *What is the number of vibrations per second necessary to produce the fifth tone ofthe scale of C?*

(p. 176.) $C_1 = 128$ vibrations. G of that scale $= 192$ vibrations per second.

8. *What is the length of each sound-wave in that tone when the temperature is zero?*

1090 ft.— 32 ft. =1058 ft. 1058 ft. ÷ 192 = 5 ft. 6 + in. (the length of each vibration).

9. *What is the number of vibrations in the fourth tone above middle C (C_2)?*

$C_2 = 256$ vibrations . $\frac{36}{24}$ = (the proportionate no. for the 5th of the scale),

$$256 \times \frac{36}{24} = 384 \text{ (the number of vibrations per second).}$$

10. *A meteor of Nov. 13, 1868, is said to have exploded at a height of 60 miles: what time would have been necessary for its sound to reach the earth?*

5280 ft. × 60 = 316,800 ft.

316,800 ft. ÷ 1090 ft. = 290 (sec.) = 4 min. 50 sec.

11. *A stone was let fall into a well, and in 4 seconds was heard to strike the bottom. How deep was the well?*

(See p. 48.) $d = 16 \times t^2$. $d = 16 \times 4^2 = 256$ ft.

12. *What time would it require for a sound to travel 5 miles in the still water of a lake?*

5280 ft. × 5 = 26,400 ft.

26,400 ft. ÷ 4700 ft. = 5.6 (sec.)

13. *How much louder will be the report of a gun to an observer at a distance of 20 rods than to one at half a mile?*

160 rods are 8 times 20 rods. The intensity of the sound is inversely as the square of the distance = $^1/_{64}$. Hence the sound is 64 times louder to the observer at 20 rods that to the one at half a mile.

14. *Does sound travel faster at the foot or at the top of a mountain?*

The density and elasticity of the air vary in the same proportion; hence if the temperature were the same on the top of a mountain that it is at the foot, the velocity of sound would be the same, but as it is always colder, the velocity is less.

15. *Why is an echo weaker than the original sound?*

Because the intensity of the sound-wave is weakened at each reflection.

16. *Why is it so fatiguing to talk through a speaking-trumpet?*

Because so much more air must be set in motion by the vocal chords. The column of air in the resonant cavity of the throat is re-enforced by all the air in the trumpet.

—When we hear a goblet or a wine-glass struck with the blade of a knife, we can distinguish three sounds, the fundamental and two harmonics.*

* Is not the ear the most perfect sense? A needlewoman will distinguish by the sound, whether it is silk or cotton that is torn. Blind people recognize

OPTICS.

224. 1. *Why is a secondary bow fainter than the primary?*

The primary is produced by one reflection and two refractions; the secondary, by two reflections and two refractions. The additional reflection weakens the ray.

Why are the colors reversed?

We can understand this by looking at Fig. 159. In one bow we see that the rays enter the drops at the top, and are refracted at the *bottom* to the eye; in the other, that the rays enter at the bottom, and are refracted at the *top* to the eye.

2. *Why can we not see around a house or through a bent tube?*

The rays of light move in straight lines.

3. *What color would a painter use if he wished to represent an opening into a dark cellar?*

Black.

4. *Is black a color?*

No; it is the absence of color

Is white?

Yes; it is the presence of all color—*i. e.*, it is the compound effect produced on the brain by seven different impressions.

5. *By holding an object nearer a light, will it increase or diminish the size of the shadow?*

It will incréase it, because more rays are intercepted.

7. *Where will we see a rainbow in the morning?*

In the west.

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the age of persons by their voices. An architect, comparing the length of two lines separated from each other, if he estimate within the 30th part, we deem very accurate; but a musician would not be considered very precise who only estimated within a quarter of a note. (128+30 = 4, nearly.) In a large orchestra, the leader will distinguish each note of each instrument. We recognize an old-time friend by the sound of his voice, when the other senses utterly fail to recall him. The musician carries in his ear the idea of the musical key and every tune in the scale, though he is constantly hearing a multitude of sounds. A tune once learned will be remembered when the words of the song are forgotten. Prof. Pepper tells us that he tuned a fork which corresponded to 64,000 vibrations per second. The first harmonic is produced by one-half the whole cord, the second by one-third, &c.

8. *Can any two spectators see the same rainbow?*

They cannot, because no two persons can be at the right angle to get the same color from a drop.

9. *Why, when the drops of water are falling through the air, does the bow appear stationary?*

Because the drops succeed each other so rapidly that they keep a constant impression on the retina.

10. *Why can a cat see in the night?*

Because the pupils of its eyes are larger, and so admit more light.

Why cannot an owl see in daylight?

The pupils of its eyes are large enough to admit of clear vision in the night, but they cannot be contracted, and so in daylight the owl becomes dazzled with the excess of light receivd.

12. *Why are we blinded when we pass quickly from a dark into a brilliantly lighted room?*

The pupils of our eyes admit too much light, but they soon contract to the proper dimensions, and we can then see distinctly. When we pass out from a lighted room into the dark street, the conditions are reversed.

13. *If the light on a distant planet is only $\frac{1}{100}$ that which we receive, how does its distance from the sun compare with ours?*

As the light is inversely as the square of the distance, the distance is $\sqrt{100} = 10$ times greater than ours.

14. *If when I sit 6 feet from a candle I receive a certain amount of light, how much will I diminish it if I sit back 6 feet further?*

As my distance from the light is doubled, the light is inversely as 2^2, or only $\frac{1}{4}$ as bright.

15. *Why do drops of rain, in falling, appear like liquid threads?*

The impression the drop makes on the retina remains until the drop reaches the ground.

16. *Why does a towel turn darker when wet?*

More of the light is transmitted, and less reflected. We see this illustrated in greasing a bit of paper. It becomes semi-transparent because more light passes through it, but looks darker itself because less light is reflected to the eye.

17. *Does color exist in the object or in the mind of the observer?*

In the mind. Color in the object can be only a peculiar property whereby a body absorbs some colors, and reflects or transmits others.

18. *Why is lather opaque, while air and a solution of soap are each transparent?*

By repeated reflections and refractions in passing through the unhomogeneous mass of lather, the rays are weakened. The principle is the same as that of deadening floors with tan-bark. (Phil., p. 161.)

19. *Why does it whiten molasses candy to pull it?*

Because the candy tends to take on the crystalline form. Crystals are homogeneous, and are, therefore, more transparent than uncrystallized bodies.

20. *Why does plastering become lighter in color as it dries?*

Because, as the water evaporates, the mortar transmits less light, and reflects more light to the eye.

21. *Why does a photographer use a kerosene oil-lamp in the "dark-room?"*

Kerosene oil-flame emits only heat and color, but no actinic rays. Some "dark-rooms" are lighted with yellow glass windows.

22. *Is the common division of colors into "cold" and "warm" verified in philosophy?*

Yes; red contains more heat than violet.

23. *Why is the image on the camera, Fig. 167, inverted?*

The rays cross each other at the focus of the double convex lens.

24. *Why is the second image seen in the mirror, Fig. 134, brighter than the first?*

The first is formed by reflection from the glass, and the second from the mercury. As the latter is a better reflector, the second image will be brighter. Each image after that will be weakened by the repeated reflection.

27. *Which can be heard at the greater distance, noise or music?*

Other things being equal, music will penetrate much further than noise. Boatmen call to each other, at a distance, in a musical tone. A band is heard above the noise of the rabble. It seems to be a wise provision of Providence that all harsh, discordant noises should perish as soon as possible, and only harmonious ones survive.

28. *Why are some bodies brilliant, and others dull?*

Some reflect the light better than others. A piece of stone coal lying in the sun's rays will shine so brilliantly that one will cease to see the coal at all, and will judge it to be a bright metal.

29. *Why can a carpenter looking along the edge of a board tell whether it is straight?*

If the edge is straight, the light will be reflected uniformly to his eye from the whole length. Any uneven places will make dark and light spots.

30. *Why can we not see out of the window after we have lighted the lamp in the evening?*

The glass reflects the light of the lamp back to our eyes, and they adapt themselves to the increased amount.

31. *Why does a ground-glass globe soften the light?*

It scatters the rays.

32. *Why can we not see through ground-glass or painted windows?*

They transmit the light irregularly to the eye, and not uniformly, like a transparent body.

33. *Why does the moon's surface appear flat?*

Because it is so distant that the eye cannot detect the difference between the distance of the centre and the circumference.

34. *Why can we see further with a telescope than with the naked eye?*

Because it furnishes us more light with which to see a distant object.

35. *Why is not snow transparent, like ice?*

Because it is unhomogeneous. See problem 18.

36. *Are there rays in the sunbeam which we cannot see?*

We cannot see the heat or the chemical rays.

37. (1) *Make two marks on a sheet of white paper, at a distance of about three inches from each other. Then closing one eye and looking steadily at one mark (though we can see both), move the paper toward the eye. A point will be reached where the eye can perceive only one of the marks; on coming nearer, both will be seen again.*

38. (2) *Prick with a pin, through a card-board, two holes closer together than the diameter of the pupil of the eye. Holding the card pretty near the eyes, look through these holes at the head of a pin. There will seem to be two pin-heads.*

39. (3) *Press the finger on one eyeball and we shall see objects double.*

Since an impression is made on the retina of each eye, it would seem that we ought always to see objects double. The nerves from both eyes are so joined, however, before they reach the brain, that this effect is avoided. If, now, we cause the image on the retina to be made on parts of the eye which do not correspond to each other, we shall obtain a double image.

40. *Why is a rainbow in the morning a sign of foul, and in the evening of fair weather?*

In the morning it indicates a formation of clouds when the temperature is rising, and therefore shows a determination to moisture. In the evening it indicates a clearing away when the temperature is falling, and hence shows a determination to dryness.

41. *Why is a red, lowering sky in the morning a sign of rain, and a brilliant red sky at night, of fair weather?*

42. *Why does a distant light, in the night, seem like a star?*

43. *Why does a bright light, in the night, seem so much nearer than it is?*

44. *Why does a ray of light, passed through a small hole, of any shape, in a card, make a round, bright spot?*

45. *Why are these spots crescent-shaped during an eclipse?*

46. *What color predominates in artificial lights?*

Yellow.

47. *Why does yellow seem white, and blue green, when seen by artificial light?*

Because the white takes on, in the yellow rays, a yellow hue, and the yellow added to the blue gives a green, hence there is no white for comparison. So, also, dark blue becomes purple, and red has a tawny hue. Magnesium light possesses all the colors of the spectrum, and hence all objects retain their natural appearance when illuminated by it.

48. *Why are we not sensible of darkness when we wink?*

Because the impression of the light is retained upon the retina during the brief interval of darkness.

HEAT.

258. 1. *Why will one's hand, on a frosty morning, freeze to a metallic door-knob sooner than to one of porcelain?*

Because the metal is a better conductor of heat than the porcelain, and hence conducts the heat from the hand faster.

2. *Why does a piece of bread toasting curl up on the side toward the fire?*

The water being expelled from the pores on that side causes the bread to shrink.

3. *Why do double windows protect from the cold?*

The non-conducting air enclosed between the window-panes keeps in the heat and keeps out the cold.

4. *Why do furnace-men wear flannel shirts in summer to keep cool, and in winter to keep warm?*

In summer the non-conducting flannel keeps out the furnace-heat, and in the winter keeps in the body-heat.

5. *Why do we blow our hands to make them warm, and our soup to make it cool?*

Our breath is warmer than our hands, but cooler than our soup.

6. *Why does snow protect the grass?*

The air enclosed between the flakes of snow is a non-conductor. No infant in its cradle is tucked in more tenderly than the coverlet of snow about the humble grass that nestles down for its winter's nap on the bosom of mother Earth.

7. *Why does water "boil away" more rapidly on some days than on others?*

Because the atmospheric pressure varies.

8. *What causes the crackling sound in a stove, when a fire is lighted?*

The expansion of the iron by the heat.

9. *Why is the tone of a piano higher in a cold room than in a warm one?*

The steel wires lengthen in a warm room, and so lower the tone.

10. *Ought an inkstand to have a large or a small mouth?*

A small mouth, to prevent evaporation.

11. *Why is there a space left between the ends of the rails on a railroad track?*

To allow room for the expansion and contraction of the rails with the changes in temperature.

12. *Why is a person liable to take cold when his clothes are damp?*

The water which evaporates from his clothes, in drying, absorbs heat from his body.

13. *What is the theory of corn-popping?*

The air in the cells of the corn expands by the heat and bursts the outer coating of the corn.

14. *Could vacuum-pans be employed in cooking?*

They could not, because the heat would not be sufficient to cook the food.

15. *Why does the air feel so chilly, in the spring, when snow and ice are melting?*

When the ice is passing into the liquid state, it absorbs heat from all surrounding objects.

16. *Why, in freezing ice-cream, do we put the ice in a wooden vessel, and the cream in a tin one?*

The non-conducting wooden vessel prevents the ice from absorbing heat from the external air, and the conducting tin vessel enables it to absorb the heat from the cream.

17. *Why does the temperature generally moderate when the snow falls?*

The vapor passing into the solid form gives off heat.

19. *Why does sprinkling a floor with water cool the air?*

The water turning to vapor absorbs heat.

20. *How low a degree of temperature can be reached with a mercurial thermometer?*

Nearly to the freezing point of mercury, −39° F.

21. *If the temperature be 70° F., what is it C.?*

$$70° - 32° = 38°. \quad 38 \div 1.8 = 21.1° \text{ C.}$$

—*If the temperature be 70° C., what is it F.?*

$$70° \times 1.8 = 126°. \quad 126° + 32° = 158° \text{ F.}$$

22. *Will dew form on an iron bridge?*

Yes, because iron is a good radiator.

On a wooden bridge?

Not so readily, because wood is a poorer radiator.

23. *Why will not corn pop when very dry?*

The pores shrink, and the corn becomes compact; only porous, tender-celled corn will pop.

24. *The interior of the earth being a melted mass, why do we get the coldest water from a deep well?*

The well extends below the influence of the sun, and not deep enough to reach the internal heat of the earth.

25. *Ought the bottom of a tea-kettle to be polished?*

No, since a polished surface would reflect the heat. We need a black, rough, sooty surface to absorb the heat rapidly.

26. *Which boils the sooner, milk or water?*

Milk, because it is so adhesive that the bubbles of steam which are formed at the bottom of the dish cannot easily escape. They therefore pile up on top of each other, and the milk boils over readily.

27. *Is it economy to keep our stoves highly polished?*

The stove-blacking used is a good radiator, but the surface should not be highly polished, as that hinders radiation.

28. *If a thermometer be held in a running stream, will it indicate the same temperature that it would in a pailful of the same water?*

It will. For the same reason that a thermometer, in the wind, will indicate the same temperature as in the still air, although the former seems to us much colder.

29. *Which makes the better holder, woollen or cotton?*

Woollen, because it is so poor a conductor of heat.

30. *Which will give out the more heat, a plain stove or one with ornamental designs?*

The latter, since it has more radiating surface

31. *Does dew fall?*

No; it forms directly where it is found. The vapor merely collects on the cold surface.

32. *What causes the "sweating" of a pitcher?*

The vapor of the air condenses on the cold pitcher. It is often a sign of rain, since it shows that the air is full of vapor easily deposited.

33. *Why is evaporation hastened in a vacuum?*

Because the pressure of the air is removed.

34. *Does stirring the ground around plants aid in the deposition of dew?*

It does, since it facilitates radiation.

35. *Why does the snow at the foot of a tree melt sooner than that in the open field?*

The dark-colored tree absorbs the sun's heat, and then radiates it out in slow, dull waves, which are absorbed by the snow.

36. *Why is the opening in a chimney made to decrease in size from bottom to top?*

Because as the heated air rises it cools and shrinks. If the chimney did not diminish in size correspondingly, currents of cold air would set down from the top.

37. *Will tea keep hot longer in a bright or in a dull tea-pot?*

In a bright one, since a polished surface retards radiation.

39. *Why is one's breath visible on a cold day?*

The vapor in the breath is condensed by the cold air.

41. *Why is light-colored clothing cooler in summer and warmer in winter than dark-colored?*

It does not absorb the heat of the sun in summer, nor the heat of the body in winter; dark-colored clothing has neither of these desirable properties.

42. *How does the heat at two feet from the fire compare with that at four feet?*

$$2^2 : 4^2 :: 1 : 4.$$

Hence it is four times greater.

43. *Why does the frost remain later in the morning upon some objects than upon others?*

Those objects which are good absorbers of heat soon become warm enough to melt the frost upon them: poor absorbers heat more slowly, and so retain the frost longer.

44. *Is it economy to use green wood?*

It is not, since the sap must be changed to vapor, and water in turning to vapor renders latent over 900° of heat. This is, of course, entirely lost to the consumer.

45. *Why does not green wood snap?*

The pores are filled with water instead of air. The water does not expand rapidly enough to burst off the coverings of the cells, and so simply oozes out gradually and is vaporized.

46. *Why will a piece of metal dropped into a glass or porcelain dish of boiling water facilitate the ebullition?*

The rougher surface of the metal aids in the formation and disentanglement of the steam-bubbles. The bubbles cling longer to a smooth than to a rough surface. This is one cause of that bumping sound often noticed when liquids are boiling in glass dishes.

47. *Which can be ignited the more easily with a burning-glass, black or white paper?*

Black paper, since it is a much better absorber of heat.

48. *Why does the air feel colder on a windy day?*

Because fresh portions of cold air are brought constantly in contact with our bodies.

49. *In what did the miracle of Gideon's fleece consist?*

Both the fleece and the hard threshing-floor were poor radiators; hence the dew would not readily form on either. The miracle consisted in its gathering each time on only one of two objects, on both of which it should gather, if on either. (Judges, vi. 37-40.)

50. *Could a burning-lens be made of ice?*

Burning-lenses have been made of that material. The rays have no heating power until the waves of ether are stopped. They do not elevate the temperature of the medium through which they pass.

51. *Why is an iceberg frequently enveloped by a fog?*

The moisture of the air is condensed upon its cold surface.

52. *Would dew gather more freely on a rusty stove than on a bright kettle?*

It would, because the rusty iron surface is a good radiator.

53. *Why is a clear night colder than a cloudy one?*

On a cloudy night the clouds reflect the radiated heat of the earth back again, and thus act as a blanket to keep the earth warm. On such a night there can be no frost or dew. On a clear night, the heat which the earth radiates passes out freely into space, and thus the earth cools rapidly.

54. *Why is no dew formed on cloudy nights?*

See last question.

55. *Water boiled at a certain place at* 200° *F.: what was the height above the sea?*

56. *On Mont Blanc boiling water is only* 84° *C.: what is the height?*

57. *Why do we use a longer tube of mercury for a barometer than a thermometer?*

58. *Which is the hottest part of a room?*

59. *Why is it hotter above a flame than at the side?*

60. *What is the difference between dew and rain?*

61. *Why will ashes keep fire overnight?*

62. *If a pane of glass and a similar plate of polished steel were laid upon the ground, in the night, upon which would the dew form most abundantly?*

The glass is a poor conductor of heat, and so would absorb little heat from the earth, while the metal would absorb it freely; the glass is a better radiator than the polished metal, and thus would become drenched with dew, while the metallic surface would be scarcely dimmed.

63. *Why is there but little dew formed in cities?*

64. *Is an abundant dew a sign of rain?*

It is. See question 32.

65. *Is there any dew formed out at sea?*

66. *Why are gardens in a valley often touched with frost, while those on the hills escape unharmed?*

The cold air settles into the valley, while the warm air rises to the hills.

67. *How are hailstones formed?*

There are two separate currents of air, one hot and charged with moisture, the other cold. The former is displaced by the latter and driven up in the atmosphere. There its vapor is condensed at the centre of the cloud into snow, and at the extremities into ice-cold water. In this cloud there is a whirling motion which collects the snow into little balls, each of which is the nucleus of a hailstone. Each of these is carried, alternately, by the whirling currents, into the snow-cloud at the centre, and the ice-cold water outside. Both give it a coating, one of snow-like, spongy ice, and the other of transparent ice. This is done with great rapidity, until at last its weight overcomes the violent upward motion which sustains it in the air, and the hailstone falls to the ground. When a hailstone is carefully examined we can see this nucleus, and these concentric layers, like the coats of an onion.*

68. *Why do we have hailstorms in summer, and not in winter?*

The small spongy hail or sleet of winter has the same origin as hailstones in summer, but there is not enough vapor in the cold air to give them the size of summer hailstones.

69. *Is the sweating of a pitcher a sign of rain?*

See question 32.

70. *Where should ice be applied, to cool water?*

At the top, because cold water falls.

71. *Why is evaporation hastened in a vacuum?*

Because the pressure of the air is removed.

72. *Is a dusty boot hotter to the foot than a polished one?*

It is, because it is a better absorber of heat.

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* The above theory is that advanced by Prof. Loomis, in his "Treatise on Meteorology." The teacher will find this work invaluable on all meteorological questions.

(Key, p. 34, Prob. 11.) The method adopted in solving this problem is merely the rough one in common use, and gives only an approximate result. If an exact answer is desired, we should take in account the time required for the sound to reach the ear. The following method may be employed:

$x =$ No. sec. for stone to fall.
$4 - x =$ " " sound to reach the ear.

$$16x^2 = (4 - x)1090.$$
$$16x^2 = 4360 - 1090x.$$

From this, by completing the square, we have

$$x = 3.7892 + \text{ seconds.}$$

Then the equation (2) $d = 16t^2$ gives the depth.

$$d = 16(3.7892+)^2 = 229 \text{ ft. and } 8.795 \text{ in.,}$$

which is the answer exact within a small fraction.

A second method (more exact)—

$$d = \text{depth of the well} = 16t^2.$$
$$t = \sqrt{\frac{d}{16}} = \frac{1}{4}\sqrt{d}.$$
$$4 - \tfrac{1}{4}\sqrt{d} = \text{No. of sec. for sound to reach the ear.}$$
$$(4 - \tfrac{1}{4}\sqrt{d})1090 = 4360 - \tfrac{1090}{4}\sqrt{d}.$$
$$4360 - \tfrac{1090}{4}\sqrt{d} = d.$$
$$\tfrac{1090}{4}\sqrt{d} = 4360 - d.$$
$$d^2 - \tfrac{331905}{4}d = -19009600.$$
$$d = 229.73 + \text{ feet.}$$

ANSWERS

TO THE PRACTICAL QUESTIONS,

AND SOLUTIONS OF THE PROBLEMS,

IN THE

FOURTEEN WEEKS' COURSE

IN

CHEMISTRY.

[The bold-faced figures refer to the pages of the Chemistry; the others to the number of the Practical Questions.]

1. *Is it likely that all the elements have been discovered?*

It is not, since several have been found lately by means of spectrum analysis. The ancients held that there are but four elements—earth, water, air, and fire; the first representing the solid form of matter, the second the liquid, the third the gaseous, and the fourth the force which changes matter from one form to another. Few of the sixty-five elements are common. Those italicised, in the table on page 12, are rare. The remarkable phenomena of allotropism would seem to indicate that, perhaps, what we now consider distinct elements may be only allotropic states of the same element. Indeed, it is possible to conceive that all substances are only allotropic forms of one universal essence. In the present state of chemistry this view cannot be proved, and is only a speculation as to what may be discovered in the future.

2. *What is the origin of the term "gas?"*

This word was first used in the 17th century. Explosions, strange noises, and lurid flames had been seen in mines, caves, &c. The alchemists, whose earthen vessels often exploded with terrific violence, commenced their experiments with prayer, and placed on their crucibles the sign of the cross—hence the name crucible from *crux* (gen. *crucis)*, a cross. All these manifestations were supposed to be the work of invisible spirits, to whom the name *gahst* or *geist*, a ghost or spirit, was applied. The miners were in special danger from these unseen adversaries, and it is said that their church service contained the petition, "From geists, good Lord, deliver us!" The names—spirits of wine, nitre, &c., are a relic of the superstitions of that time.

3. *If the air were pure O, what bodies would escape combustion in a conflagration?*

The stones, mortar, &c., which being already combined with O and other elements, and having their chemical affinities satisfied, are hence termed "burnt bodies."

4. *Why will lime added to hard water often soften it?*

The lime will combine with the free carbonic acid absorbed by the water. This renders the water incapable of holding in solution as much carbonate of lime as before, which is then precipitated, and the water thus partly softened.

5. *Why will stirring a wood fire quicken the flame, but a coal fire, will deaden it?*

Stirring a fire lets in more O, which quickens a wood fire but reduces the temperature of a coal fire below the point of union between O and coal. It is really based on the fact that a higher temperature is requisite to burn coal than wood.

6. *Why does blowing on a fire quicken the flame, but on a lamp extinguishes it?*

The same principle applies as in the last question. In addition, the force of our breath often drives the flame off the wick mechanically.

7. *Why will oyster-shells placed on the grate of a coal fire prevent the formation of clinkers?*

The lime of the shells forms a flux with the silicates contained in the coal, and thus renders them more fusible.

8. *What alkali abounds in sea-weed?*

Soda.

9. *What alkali abounds in land-plants?*

Potash. The former salt is a constituent of sea-water, and the latter of rocks which decompose to form the soil.

10. *How is lime-water made from oyster-shells?*

The oyster-shells, in burning, lose their CO_2. This leaves the lime uncombined; hence it readily dissolves in water.

11. *What other tests of lead than HS?*

KI gives a yellow precipitate, NH_4S a black, and SO_3 a white one.

12. *Will not lime lose its beneficial effect upon soil after a time?*

Lime acts in various ways to improve the fertility of a soil. It corrects its acidity, aids in the decomposition of the rocky constituents, hastens the decay of the humus, and also makes the soil more porous. It does not, however, benefit the growing plant directly, but works up other materials in the soil. It therefore loses its effect after a time. The Belgian farmers have a proverb:

> "Much lime and no manure
> Make farm and farmer poorer."

13. *What is the derivation of the term zinc?*

The name is probably derived from the German *zinken*, signifying "nails," and is applied to this metal on account of its frequently forming pointed particles somewhat resembling nails, when melted and suddenly poured into water. (Griffiths.)

14. *What is the action of permanganate of potash* (chameleon mineral) *as a disinfectant?*

It gives up its O to oxydize the organic impurities of the water in which they collect.

15. *Do all fish die when taken out of the water?*

No. Some fish have an apparatus for moistening their gills. They can therefore crawl about in the grass, and even migrate from one stream to another.

16. *What proof have we that H is a metal?*

Besides that given in the Chemistry, the "sodium amalgam" is thought by some to be an additional proof. Heat moderately in a test-tube a little mercury with a grain or two of sodium. The two metals will combine, forming a pasty amalgam. When cold, pour over it a solution of sal-ammoniac. The amalgam will immediately swell up to eight or ten times its original bulk, *retaining, however, its metallic lustre.* It is thought that H is the metal which puffs out and combines with the mercury, since otherwise we would be compelled to suppose that NH_4 is a metallic element, instead of a compound radical, as is generally believed.

17. *Why does not frozen meat spoil?*

The cold protects from chemical change. The bodies of mammoths have been found in the frozen soil of Arctic regions so perfectly preserved that the dogs ate the flesh. How long the animals had been there we cannot tell, but certainly for ages. In 1861 the mangled remains of three guides were found at the foot of the Glacier de Boissons, in Switzerland. They had been lost in an avalanche on the grand plateau of Mont Blanc, forty-one years before.

18. *Give an illustration of the effect of food on the disposition of animals.*

Bears which feed on acorns are mild and tractable, while those of the polar regions, which live on flesh alone, are fierce and ungovernable.

19. *Compare the chemical action of the animal with that of the plant.*

The animal lives on *organized* materials, taking up O and evolving CO_2, and other oxydized products. The plant lives on *unorganized* materials, CO_2, HO, NH_3, and salts, organizing them and evolving O. The function of the animal is oxydation; that of the plant, reduction. The food of the plant serves merely to increase its bulk; that of the animal is employed to replace the material worn out by the active operations of life. The animal obtains the energy necessary for its existence from the oxydation of its own body; the plant obtains the energy necessary for the organization of its food directly from the sun.

20. *Show how man is made mainly of condensed air.*

Science has demonstrated that man is formed of condensed air; that he lives on condensed as well as uncondensed air, and clothes himself in condensed air, that he prepares his food by means of condensed air, and by means of the same agent moves the heaviest weights with the velocity of the wind. But the strangest part of the matter is, that thousands of these tabernacles formed of condensed air, and going on two legs, occasionally, and on account of the production and supply of these forms of condensed air which they require for food and clothing, or on account of their honor and power, destroy each other in pitched battles by means of condensed air.—LIEBIG.

17. 1. *In making O from chlorate of potash ($KO.ClO_5$), how much can be obtained from two pounds of the salt?*

$6O = 48 =$ equivalent of constituent.
$KO.ClO_5 = 122.5 =$ " " compound.
$x =$ weight of constituent.
2 lbs. = " " compound.
$6O : KO.ClO_5 :: x : 2$ lbs.
$48 : 122.5 :: x : 2$ lbs.
$x = \frac{192}{245} = .78$ lb. (O).

2. *In making H, zinc is used. How much sulphate of zinc ($ZnO.SO_3+7HO$) will be formed from 2 lbs. of the metal?*

$Zn = 32.6 =$ equivalent of the constituent.
$ZnO.SO_3+7HO = 143.6 =$ " " compound.
2 lbs. = weight of the constituent.
$x =$ " " compound.
$Zn : (ZnO.SO_3+7HO) :: 2$ lbs. $: x$.
$32.6 : 143.6 :: 2$ lb. $: x$.
$x = 8.8$ lbs. (white vitriol, sulp. zinc).

3. *How much SO_3 will be required to make 50 lbs. sulphate of iron ($FeO.SO_3+7HO$)?*

$SO_3 = 40 =$ equivalent of the constituent.
$FeO.SO_3+7HO = 139 =$ " " compound.
$x =$ weight of the constituent.
50 lbs. $=$ " " compound.
$SO_3 : (FeO.SO_3+7HO) :: x : 50$ lbs.
$40 : 139 :: x : 50$ lbs.
$x = 14\frac{54}{139}$ lbs. (green vitriol, sulphate of iron).

4. *The equivalent of the chloride of sodium (salt) is* 58.5. *In* 10 *lbs. there are* $6\frac{8}{117}$ *lbs. of chlorine: what is the equivalent of Cl?*

$x =$ equivalent of the given constituent.
$58.5 =$ " " " compound.
$6\frac{8}{117}$ lbs. $=$ weight of the given constituent.
10 lbs. $=$ " " " compound.
$x : 58.5 :: 6\frac{8}{117}$ lbs. $: 10$ lbs.
$x = 35.5$.

5. *In* 20 *grains of bromide of potassium there are* $6\frac{66}{119}$ *grains of potassium: the equivalent of potassium being* 39, *what is the equivalent of the bromide of potassium?*

$39 =$ equivalent of the given constituent.
$x =$ " " " compound.
$6\frac{66}{119}$ grs. $=$ weight of the given constituent.
20 grs. $=$ " " " compound.
$39 : x :: 6\frac{66}{119}$ grs. $: 20$ grs.
$x = 119$.

6. *In* 14 *lbs. of iron-rust* (Fe_2O_3) *how much O?*

$3O = 24 =$ equivalent of the given constituent.
$Fe_2O_3 = 80 =$ " " " compound.
$x =$ weight of the given constituent.
14 lbs. $=$ " " " compound.
$24 : 80 :: x : 14$ lbs.
$x = 4\,{}^1/_5$ lbs. (O).

7. *In* 20 *lbs. of glass* ($NaO.SiO_2+CaO.SiO_2$) *how many lbs. of sand* (SiO_2)?

$2\ SiO_2 = 60 =$ equivalent of the given constituent.
$(NaO.SiO_2+CaO.SiO_2) = 119 =$ " " " compound.
$x =$ weight of the given constituent.
20 lbs. $=$ " " " compound.
$60 : 119 :: x : 20$ lbs.
$x = 10\frac{10}{119}$ lbs. (SiO_2)

8. *In a 25 lb. sack of salt (NaCl) how many lbs. of the metal sodium?*

Na = 23 = equivalent of the constituent.
NaCl = 58.5 = " " compound.
x = weight of the constituent.
25 lbs. = " " compound.
23 : 58.5 :: x : 25 lbs.
$x = 9\frac{97}{117}$ lbs. (Na).

229. 5. *What weight of O is contained in 60 grs. of $KO.ClO_5$?*

6O = 48 = equivalent of constituent.
$KO.ClO_5 = 122\frac{1}{2}$ = " " compound.
x = weight of constituent.
60 grs. = " " compound.
48 : $122\frac{1}{2}$ :: x : 60 grs.
$x = 23\frac{25}{49}$ grs. (O).

6. *How much KCl will be formed in preparing 80 grs. of O?*

First find how much $KO.ClO_5$ will be required to make 80 grs. of O, and then subtract the 80 grs. of O from the amount, and the remainder will be the KCl. The constituent and compound are the same as in the last problem.

48 : $122\frac{1}{2}$ :: 80 grs. : x
x = 204.16 grs.
204.16 grs. — 80 grs. = 124.16 grs. (KCl).

7. *How much H can be made from 10 lbs. of Zn?*

First find how much ZnO 10 lbs. of Zn will form; second, subtract the 10 lbs. of Zn, and the remainder is the O which came from the water. This O formed $\frac{8}{9}$ of the water, and the remaining $\frac{1}{9}$ is the H set free.

Zn = 32.5 = equivalent of the constituent.
ZnO = 40.5 = " " compound.
10 lbs. = weight of the constituent.
x = " " compound.
35.5 : 40.5 :: 10 lbs. : x.
x = 12.461 lbs. (ZnO). 12.461 lbs. ZnO — 10 lbs. Zn = 2.461 lbs. (O).
2.461 lbs. ÷ 8 = .307 lbs. (H).

8. *How much H can be made from 50 lbs. of water?*

$H = 1 =$ equivalent of given constituent.
$HO = 9 =$ " " compound.
$x =$ weight of given constituent.
50 lbs. $=$ " " compound.
$1 : 9 :: x : 50$ lbs.
$x = 5\,^5/_9$ lbs. (H).

More simply, $\frac{1}{9}$ of water is H; hence

$$50 \text{ lbs.} \div 9 = 5\,^5/_9 \text{ lbs. (H)}.$$

9. *How much saltpetre will be required to make* 18 *lbs. of aquafortis?*

$NO_5 = 54 =$ equivalent of given constituent.
$KO.NO_5 = 101 =$ " " compound.
18 lbs. $=$ weight of given constituent.
$x =$ " " compound.
$54 : 101 :: 18$ lbs. $: x$.
$x = 33\,^2/_3$ lbs. (saltpetre).

10. *How much oil of vitriol will be required to decompose* 6 *lbs. of saltpetre?*

First find how much KO in 6 lbs. of $KO.NO_5$, next how much $KO.SO_3$ that amount of KO will make, and lastly subtract the KO from the $KO.SO_3$, and the remainder will be the SO_3. In both cases we neglect the HO combined in the salts and the acid.

$KO : KO.NO_5 :: x : 6$ lbs.
$47 : 101 :: x : 6$ lbs.
$x = 2.79$ lbs. (KO).
$KO : KO.SO_3 :: 2.79$ lbs $: x$.
$47 : 87 :: 2.79$ lbs. $: x$.
$x = 5.16$ lbs. ($KO.SO_3$).
5.16 lbs. ($KO.SO_3$) $-$ 2.79 lbs. (KO) $=$ 2.37 lbs. (SO_3).

11. *How much HO will be decomposed by one drachm of K, and how much KO will be formed?*

First find how much KO 1 dr. of K will form, then subtract from the KO the drachm of K, and the remainder is the O, which must be $\frac{8}{9}$ of the water from which it is obtained.

$$K : KO :: 1 \text{ dr.} : x.$$
$$39 : 47 :: 1 \text{ dr.} : x.$$
$$x = 1\tfrac{8}{39} \text{ drs. (KO).}$$
$$1\tfrac{8}{39} \text{ drs.} - 1 \text{ dr.} = \tfrac{8}{39} \text{ dr., the amount of O.}$$
$$\text{The HO is } {}^9/_8 \text{ of } {}^8/_{39} \text{ dr.} = {}^3/_{13} \text{ dr. (HO).}$$

12. *What weight of nitrous oxyd will be formed from the decomposition of* 6 *oz. of nitrate of ammonia?*

$$2\,NO : NH_4O.NO_5 :: x : 6 \text{ oz.}$$
$$x = 3\,{}^3/_{10} \text{ oz. (NO).}$$

13. *How much sal-ammoniac would be required to make* 2 *lbs. of NH_3?*

$$NH_3 : NH_4Cl :: 2 \text{ lbs.} : x.$$
$$17 : 53.5 :: 2 \text{ lbs.} : x.$$
$$x = 6\,{}^5/_{17} \text{ lbs. (sal-ammoniac).}$$

14. *How much CO_2 will be formed in the combustion of* 30 *grs. of CO?*

$$CO : CO_2 :: 30 \text{ grs.} : x.$$
$$14 : 22 :: 30 \text{ grs.} : x.$$
$$x = 47\,{}^1/_7 \text{ grs. } (CO_2).$$

15. *What weight of carbonate of soda* (sal-soda) *would be required to evolve* 12 *lbs. of CO_2?*

$$CO_2 : NaO.CO_2 :: 12 \text{ lbs.} : x.$$
$$22 : 53 :: 12 \text{ lbs.} : x.$$
$$x = 28\,{}^{10}/_{11} \text{ lbs. } (NaO.CO_2).$$

16. *What weight of bicarbonate of soda ($NaO.2CO_2$, "soda") would evolve* 12 *lbs. of CO_2?*

$$2CO_2 : NaO.2CO_2 :: 12 \text{ lbs.} : x.$$
$$44 : 75 :: 12 \text{ lbs.} : x.$$
$$x = 20\,{}^5/_{11} \text{ lbs. ("soda").}$$

17. *What weight of C is there in a ton of CO_2?*

$$C : CO_2 :: x : 2000 \text{ lbs.}$$
$$6 : 22 :: x : 2000 \text{ lbs.}$$
$$x = 545\,{}^5/_{11} \text{ lbs. (C).}$$

18. *How much O is consumed in burning a ton of C?*

3*

$$C : CO_2 :: 2000 \text{ lbs.} : x.$$
$$6 : 22 :: 2000 \text{ lbs.} : x$$
$$x = 7333\,{}^1/_3 \text{ lbs. } (CO_2).$$
$$7333\,{}^1/_3 - 2000 \text{ lbs.} = 5333\,{}^1/_3 \text{ lbs. } (O).$$

More simply:—

$$C : 2O :: 2000 \text{ lbs.} : x.$$
$$x = 5333\,{}^1/_3 \text{ lbs.}$$

19. *In burning a charge of* 10 *lbs. of gunpowder, find the weight of the several products formed.*

(See page 107.)

$$(1.)\ KS : (KO.NO_5 + S + 3C) :: x : 10 \text{ lbs.}$$
$$55 : 135 :: x : 10 \text{ lbs.}$$
$$x = 4\,{}^2/_{27} \text{ lbs. } (KS).$$
$$(2.)\ N : (KO.NO_5 + S + 3C) :: x : 10 \text{ lbs.}$$
$$14 : 135 :: x : 10 \text{ lbs.}$$
$$x = 1\,{}^1/_{27} \text{ lbs. } (N).$$
$$(3.)\ 3CO_2 : (KO.NO_5 + S + 3C) :: x : 10 \text{ lbs.}$$
$$66 : 135 :: x : 10 \text{ lbs.}$$
$$x = 4\,{}^{24}/_{27} \text{ lbs. } (CO_2).$$

20. *What weight of common salt would be required to form* 25 *lbs. of muriatic acid (HCl)?*

$$Cl : HCl :: x : 25 \text{ lbs.}$$
$$35.5 : 36.5 :: x : 25 \text{ lbs.}$$
$$x = 24.3 \text{ lbs. } (Cl).$$
$$Cl : NaCl :: 24.3 \text{ lbs.} : x.$$
$$35.5 : 58.5 :: 24.3 \text{ lbs.} : x.$$
$$x = 4040.044 \text{ lbs. } (NaCl).$$

21. *HCl of a specific gravity of* 1.2 *contains about* 40 *per cent. of the acid. This is very strong commercial acid. What weight of this acid could be formed by the HCl acid gas produced in the reaction named in the preceding problem?*

If 25 lbs. = 40 per cent., then 100 per cent. = 2.5 times 25 lbs. = $62\,{}^1/_2$ lbs.

22. *What weight of hydriodic acid (HI) is formed from a drachm of iodine?*

$$I : HI :: 1 \text{ dr.} : x.$$
$$127 : 128 :: 1 \text{ dr.} : x.$$
$$x = 1\tfrac{1}{127} \text{ drs. } (HI).$$

23. *What weight of Glauber salt can be formed from* 100 *lbs. of oil of vitriol?* *

$SO_3 : NaO.SO_3 :: 100$ lbs. $: x$.
$40 : 71 :: 100$ lbs. $: x$.
$x = 177.5$ lbs. ($NaO.SO_3$).

24. *What weight of S is there in* 10 *grs. of sulphide of hydrogen?*

$S : HS :: x : 10$ grs.
$16 : 17 :: x : 10$ grs.
$x = 9\,{}^7/_{17}$ grs. (S).

25. *How much O is required to change a lb. of SO_2 to SO_3?*

$SO_2 : SO_3 :: 1$ lb. $: x$.
$32 : 40 :: 1$ lb. $: x$.
$x = 1\,{}^1/_4$ lb. (SO_3).
$1\,{}^1/_4$ lb. $- 1$ lb. $= {}^1/_4$ lb. (O).

26. *How much phosphorus in* 40 *lbs. of phosphate of lime?*

(See page 245.) $P : 3CaO.PO_5 :: x : 40$ lbs.
$31 : 155 :: x : 40$ lbs.
$x = 8$ lbs. (P).

27. *How much P in* 40 *lbs. of the superphosphate of lime?*

$P : CaO.PO_5 :: x : 40$ lbs.
$31 : 99 :: x : 40$ lbs.
$x = 12\,{}^{52}/_{99}$ lbs. (P).

28. *How much phosphate of lime will an oz. of P make?*

$P : 3CaO.PO_5 :: 1$ oz. $: x$.
$31 : 155 :: 1$ oz. $: x$.
$x = 5$ oz. ($3CaO.PO_5$).

29. *How many lbs. of HO in* 186 *lbs. of $SO_3.3HO$?*

$3HO : SO_3.3HO :: x : 186$ lbs.
$27 : 67 :: x : 186$ lbs.
$x = 74\,{}^{64}/_{67}$ lbs. (HO).

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* In this, as in the other problems, the HO contained in the acid and in the salt is neglected, since it is a variable quantity, and the examples are merely for practice.

30. *How much CO_2 is formed in the combustion of* 1 *ton of C?*

$$C : CO_2 :: 2000 \text{ lbs.} : x.$$
$$C : 22 :: 2000 \text{ lbs.} : x.$$
$$x = 7333\,^1/_3 \text{ lbs. } (CO_2).$$

31. *What weight of S is there in a ton of iron pyrites?*

$$2S : FeS_2 :: x : 2000 \text{ lbs.}$$
$$32 : 60 :: x : 2000 \text{ lbs.}$$
$$x = 1066\,^2/_3 \text{ lbs. } (S).$$

32. *What weight of copperas could be made from* 500 *lbs. of iron pyrites?*

In forming $FeO.SO_3$ from FeS_2 only one atom of S is required; hence the 500 lbs. of iron pyrites really contain but $366\,^2/_3$ lbs. of FeS, which will, at a single reaction, form copperas; by oxydation from the air, the remaining atom of S would doubtless be used afterward. The problem might be solved as well, perhaps, by taking either the Fe or the S alone as the constituent.

$$FeS : (FeO.SO_3+7HO) :: 366\,^2/_3 \text{ lbs. } (FeS) : x.$$
$$44 : 139 :: 366\,^2/_3 \text{ lbs.} : x.$$
$$x = 1158.3 \text{ lbs. } (FeO.SO_3+7HO).$$

33. *What weight of H is there in a pound of heavy carburetted hydrogen?*

$$4H : C_4H_4 :: x : 1 \text{ lb.}$$
$$4 : 28 :: x :: 1 \text{ lb.}$$
$$x = {}^1/_7 \text{ lb. } (H).$$

34. *How much O would be required to oxydize the metallic copper which could be reduced from its oxyd by passing over it, when white-hot,* 20 *grs. of H gas?*

The same amount of O would be required to oxydize the copper that was taken from it when it was reduced from its oxyd. The H passing over it when white-hot takes out its O and forms HO. H is always $\frac{1}{9}$ of the HO. The H = 20 grs.; hence the HO = 9 times 20 grs. = 180 grs. 180 grs. (HO) — 20 grs. (H) = 160 grs. (O).

35. *How much O would be required to oxydize the metallic iron which could be reduced in the same manner by* 10 *grs. of H gas?*

Following the same reasoning as in the last problem, we have

$$H = 10 \text{ grs.}; \text{ hence the } HO = 9 \text{ times } 10 \text{ grs.} = 90 \text{ grs.}$$
$$90 \text{ grs. } (HO) - 10 \text{ grs. } (H) = 80 \text{ grs. } (O).$$

36. *What weight of N is there in* 10 *lbs. of* $NH_3.HO$*?*

$$N : NH_3.HO :: x : 10 \text{ lbs.}$$
$$14 : 26 :: x : 10 \text{ lbs.}$$
$$x = 5\,{}^5/_{13} \text{ lbs. } (N).$$

37. *How much* $KO.ClO_5$ *would be required to evolve sufficient O to burn the H produced by the decomposition of* 2 *lbs. of HO?*

$\frac{8}{9}$ of HO is O; hence 2 lbs. of HO will produce, when decomposed, $1\frac{7}{9}$ lbs. O. The problem is, then, how much $KO.ClO_5$ would be required to furnish $1\frac{7}{9}$ lbs. O?

$$6O : KO.ClO_5 : 1.77 \text{ lbs.} : x.$$
$$48 : 122.5 :: 1.77 \text{ lbs.} : x.$$
$$x = 4.51 \text{ lbs. } (KO.ClO_5).$$

(If the common fractions are used in solving this problem, the answer is $4\frac{29}{54}$ lbs.)

38. *How much H must be burned to produce a ton of water?*

$$H : HO : x : 2000 \text{ lbs.}$$
$$1 : 9 :: x : 2000 \text{ lbs.}$$
$$x = 222\,{}^2/_9 \text{ lbs. } (H).$$

39. *How much S is there in a lb. of* SO_2*?*

$$S : SO_2 :: x : 1 \text{ lb.}$$
$$16 : 32 :: x : 1 \text{ lb.}$$
$$x = {}^1/_2 \text{ lb. } (S).$$

40. *Find how much "soda" is formed from* 500 *lbs. of salt.*

41. *Find the amount of Glauber salt produced in the first step, with the charge just named.*

42. *Find the amount of HCl produced.*

43. *Find how much sulphuret of sodium is formed in the second step.*

44. *Find how much sulphuret of calcium is made*

45. *Find how much sulphur could be saved (if none were lost) from the CaS.*

The following reactions show the chemical changes which take place in the various stages:

$$(1)\quad NaCl + SO_3HO = NaO.SO_3 + HCl.$$

$$(2)\quad \begin{cases} NaO.SO_3 + 2C = NaS + 2CO_2. \\ NaS + CaO.CO_2 = CaS + NaO.CO_2. \end{cases}$$

From the (1) reaction we find how much Glauber salt will be made from 500 lbs. of common salt. To do this we first find how much Na there is in 500 lbs. NaCl; and, secondly, how much $NaO.SO_3$ that amount of Na will make.

$$Na : NaCl :: x : 500 \text{ lbs.}$$
$$23 : 58.5 :: x : 500 \text{ lbs.}$$
$$x = 196\tfrac{68}{117} \text{ lbs. (Na).}$$
$$Na : NaO.SO_3 :: 196\tfrac{68}{117} \text{ lbs.} : x.$$
$$23 : 71 :: 196\tfrac{68}{117} : x.$$
$$= 606\tfrac{98}{117} \text{ lbs. } (NaO.SO_3). \quad \textit{Ans. to 41st prob.}$$

$$Na : NaO.CO_2 :: 196\tfrac{68}{117} \text{ lbs. (Na)} : x.$$
$$23 : 53 : 196\tfrac{68}{117} \text{ lbs.} : x.$$
$$x = 452\tfrac{116}{117} \text{ lbs. } (NaO.CO_2, \text{ "Soda"}). \quad \textit{Ans. to 40th prob.}$$

$$Cl : NaCl :: x : 500 \text{ lbs.}$$
$$35.5 : 58.5 :: x : 500 \text{ lbs.}$$
$$x = 303\tfrac{49}{117} \text{ lbs. (Cl).}$$
$$Cl : HCl :: 303\tfrac{49}{117} \text{ lbs.} : x.$$
$$35.5 : 36.5 :: 303\tfrac{49}{117} \text{ lbs.} : x.$$
$$x = 311\tfrac{113}{117} \text{ lbs. (HCl).} \quad \textit{Ans. to 42d prob.}$$

$$Na : NaS :: 196\tfrac{68}{117} \text{ lbs. (Na)} : x.$$
$$23 : 39 :: 196\tfrac{68}{117} \text{ lbs.} : x.$$
$$x = 333\tfrac{1}{3} \text{ lbs. (NaS).} \quad \textit{Ans. to 43d prob.}$$

$$333\tfrac{1}{3} \text{ lbs. (NaS)} - 196\tfrac{68}{117} \text{ lbs. (Na)} = 136\tfrac{88}{117} \text{ lbs. (S).} \quad \textit{Ans. to prob. 45.}$$
$$S : CaS :: 136\tfrac{88}{117} \text{ lbs. (S)} : x.$$
$$x = 307\tfrac{9}{13} \text{ lbs. (CaS).} \quad \textit{Ans. to 44th prob.}$$

46. *How many lbs. of HCl would be required to neutralize sufficient carbonate of ammonia to form a 30 lb. cake of sal-ammoniac ($NH_4.Cl$)?*

First find how much Cl there is in a 30 lb. cake of sal-ammoniac; second, how much HCl would contain that amount of Cl.

$$Cl : NH_4Cl :: x : 30 \text{ lbs.}$$
$$35.5 : 53.5 :: x : 30 \text{ lbs.}$$
$$x = 19.9 \text{ lbs. (Cl).}$$
$$Cl : HCl :: 19.9 \text{ lbs.} : x.$$
$$35.5 : 36.5 :: 19.9 \text{ lbs.} : x.$$
$$x = 20.4 \text{ lbs. (HCl).}$$

47. *How much S is there in a ton of plaster (gypsum)?*

$$S : CaO.SO_3 :: x : 2000 \text{ lbs.}$$
$$16 : 68 :: x : 2000 \text{ lbs.}$$
$$x = 470.58 \text{ lbs. (S).}$$

48. *How much aluminum is there in a ton of clay?*

$$2Al : Al_2O_3.SiO_2 :: x : 2000 \text{ lbs.}$$
$$27.4 : 81.4 :: x : 2000 \text{ lbs.}$$
$$x = 673.2 \text{ lbs. (Al).}$$

49. *How much K is there in* 10 *lbs. of alum?*

$$K : (KO.SO_3 + Al_2O_3.3SO_3 + 24HO) : x : 10 \text{ lbs.}$$
$$39 : 474.4 :: x : 10 \text{ lbs.}$$
$$x = .82 \text{ lb. (K).}$$

50. *How much white-lead ($PbO.CO_2$) could be made from* 1 *lb. of litharge?*

$$Pb : PbO :: x : 1 \text{ lb.}$$
$$103 : 111.6 :: x : 1 \text{ lb.}$$
$$x = .92 \text{ lb. (Pb) in 1 lb. of litharge.}$$
$$Pb : PbO.CO_2 :: .92 \text{ lb.} : x.$$
$$103 : 133 :: .92 : x.$$
$$x = 1.1 \text{ lb. } (PbO.CO_2).$$

51. *How many lbs. of C would be required to reduce* 40 *tons of brown hematite ($2Fe_2O_3.3HO$)?*

In the intense heat of the furnace the 3HO would be decomposed, and so only sufficient C would be required to burn the 6 atoms of O in the $2Fe_2O_3$. In 40 tons of brown hematite there are 34.22 of the base.

$$6O : 2Fe_2O_3 :: x : 34.22 \text{ tons.}$$
$$48 : 160 :: x : 34.22 \text{ tons.}$$
$$x = 10.26 \text{ tons (O).}$$

Eight-elevenths of CO_2 is O; if 10.26 tons is $\frac{8}{11}$, it would require 3.84 tons of C to burn 10.26 tons of O, and thus reduce 40 tons of hematite.

52. *In 60 lbs. of heavy spar (sulphate of baryta) how much S is there?*

$$S : BaO.SO_3 :: x : 60 \text{ lbs.}$$
$$16 : 116.5 :: x : 60 \text{ lbs.}$$
$$x = 8.2 \text{ lbs. (S).}$$

53. *How much alum can be made from 1 cwt. of potash?*

$$KO : (KO.SO_3 + Al_2O_3.3SO_3 + 24HO) : 100 \text{ lb.} : x.$$
$$47 : 474.4 :: 100 \text{ lbs.} : x.$$
$$x = 1009.3 + \text{lbs. (alum).}$$

ANSWERS

TO THE PRACTICAL QUESTIONS

IN THE

FOURTEEN WEEKS' COURSE

IN

DESCRIPTIVE ASTRONOMY.

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1. *Did Tycho Brahe have a telescope?*

No. Galileo invented the telescope.

2. *Suppose one should watch the sky, on a winter's evening, from* 6 P. M. *to* 6 A. M., *what portion of the celestial sphere would he see?*

All that is ever seen in his latitude.

3. *How do we find what proportion of the sun's heat reaches the earth?*

Calculate the surface of a sphere whose radius is the distance of the earth from the sun, and then estimate what proportion of that area the earth occupies.

4. *How many real motions has the sun?*

Two. One around its axis, and one with the solar system around the Pleiades.

5. *How many apparent motions has the sun?*

Three. One along the ecliptic,—its yearly motion; one through the heavens,—its daily motion; and one N. and S.

6. *How many real motions has the earth?*

Three. One on its axis; one around the sun; and a third, its "wabbling motion," which causes Precession.

7. *Can any inferior planet have an elongation of 90°?*

No. Venus recedes only 48° from the sun.

8. *How do we know the heat of the sun's rays at any planet?*

The intensity of the heat and light vary inversely as the square of the distance.

9. *Can you give any other proof than that named in the book, of the rotundity of the earth?*

Aeronauts, when at a proper height, can distinctly see the curving form of the earth's surface.

10. *In what way is the force which acts on a spinning-top opposite to that which produces precession* (p. 125)?

Gravity, acting on the top, tends to draw C P (Fig. 34) *from* the perpendicular. The attraction of the sun, acting on the bulging mass of the earth's equator, tends to draw C P *toward* the perpendicular.

11. *Why is the Tropic of Cancer placed where it is?*

Because it is the farthest place north where the sun is ever seen directly overhead.

12. *Why is the Tropic of Cancer so called?*

When named, the sun was probably in that constellation at the time of the summer solstice. Now, owing to the precession of the equinoxes, the sun is in the constellation Gemini, and to be exact, it should be called the Tropic of Gemini. It is still, however, the sign Cancer, as before. The same reasoning applies to the Tropic of Capricorn, which is now in the constellation Sagittarius.

13. *In Greenland, at what part of the year will the midnight sun be seen due north?*

At the summer solstice.

14. *How do we know that the moon has little if any atmosphere?*

Because when the moon occults a star, there is no refraction of the star's true place.

15. *When is the moon seen high in the eastern sky in the afternoon, long before the sun sets?*

During the second quarter before it comes into opposition.

16. *Why is the Ecliptic so called?*

Because eclipses always occur within it.

17. *Why is it that the sun in summer shines on the north side of some houses both at rising and setting, but in winter never does?*

Since at the summer solstice the sun rises and sets north of the E. and W. points, it will rise and set on the north side of a house which stands exactly N. and S. At the winter solstice the sun rises and sets S. of the E. and W. points

TABLE OF THE MINOR PLANETS.

No.	*Name.*	*Date of Discovery.*			*Discoverer.*	*Sidereal Revolution (Days.)*
1	Ceres	1801,	January	1	Piazzi	1680
2	Pallas	1802,	March	28	Olbers	1682
3	Juno	1804,	Sept.	1	Harding	1596
4	Vesta	1807,	March	29	Olbers	1326
5	Astræa	1845,	December	8	Hencke	1512
6	Hebe	1847,	July	1	Hencke	1379
7	Iris	1847,	August	13	Hind	1346
8	Flora	1847,	October	18	Hind	1193
9	Metis	1848,	April	25	Graham	1346
10	Hygieia	1849,	April	12	Gasparis	2043
11	Parthenope	1850,	May	11	Luther	1403
12	Victoria	1850,	Sept.	13	Hind	1303
13	Egeria	1850,	Nov.	2	Gasparis	1511
14	Irene	1851,	May	19	Hind	1519
15	Eunomia	1851,	July	29	Gasparis	1570
16	Psyche	1852,	March	17	Gasparis	1828
17	Thetis	1852,	April	17	Luther	1421
18	Melpomene	1852,	June	24	Hind	1271
19	Fortuna	1852,	August	22	Hind	1393
20	Massalia	1852,	Sept.	19	Gasparis	1365
21	Lutetia	1852,	Nov.	15	Goldschmidt	1388
22	Calliope	1852,	Nov.	16	Hind	1813
23	Thalia	1852,	Dec.	15	Hind	1556
24	Themis	1853,	April	5	Gasparis	2036
25	Phocæa	1853,	April	7	Chacornac	1358
26	Proserpine	1853,	May	5	Luther	1580
27	Euterpe	1853,	Nov.	8	Hind	1313
28	Bellona	1854,	March	1	Luther	1692
29	Amphitrite	1854,	March	1	Marth	1492
30	Urania	1854,	July	22	Hind	1329
31	Euphrosyne	1854,	Sept.	1	Ferguson	2048
32	Pomona	1854,	October	26	Goldschmidt	1521
33	Polyhymnia	1854,	October	28	Chacornac	1778
34	Circe	1855,	April	6	Chacornac	1609
35	Leucothea	1855,	April	19	Luther	1903
36	Atalanta	1855,	October	5	Goldschmidt	1664
37	Fides	1855,	October	5	Luther	1569
38	Leda	1856,	January	12	Chacornac	1657
39	Lætitia	1856,	February	8	Chacornac	1684
40	Harmonia	1856,	March	31	Goldschmidt	1247
41	Daphne	1856,	May	22	Goldschmidt	1681
42	Isis	1856,	May	23	Pogson	1392
43	Ariadne	1857,	April	15	Pogson	1195
44	Nysa	1857,	May	27	Goldschmidt	1379
45	Eugenia	1857,	June	27	Goldschmidt	1638
46	Hestia	1857,	August	16	Pogson	1470
47	Aglaia	1857,	Sept.	15	Luther	1788
48	Doris	1857,	Sept.	19	Goldschmidt	2003
49	Pales	1857,	Sept.	19	Goldschmidt	1975
50	Virginia	1857,	October	4	Ferguson	1576
51	Nemausa	1858,	January	22	Laurent	1333
52	Europa	1858,	February	4	Goldschmidt	1993
53	Calypso	1858,	April	4	Luther	1548
54	Alexandra	1858,	Sept.	10	Goldschmidt	1634
55	Pandora	1858,	Sept.	10	Searle	1674

No.	Name.	Date of Discovery.			Discoverer.	Sidereal Revolution (Days.)
56	Melete*	1857,	Sept.	9	Goldschmidt	1526
57	Mnemosyne	1859,	Sept.	22	Luther	2049
58	Concordia	1860,	March	24	Luther	1615
59	Elpis	1860,	Sept.	12	Chacornac	1634
60	Echo	1860,	Sept.	15	Ferguson	1352
61	Danaë	1860,	Sept.	9	Goldschmidt	1902
62	Erato	1860,	Sept.	14	Förster and Lesser.	2023
63	Ausonia	1861,	February	10	Gasparis	1355
64	Angelina	1861,	March	4	Tempel	1601
65	Cybele	1861,	March	8	Tempel	2311
66	Maia	1861,	April	9	Tuttle	1588
67	Asia	1861,	April	17	Pogson	1375
68	Leto	1861,	April	29	Luther	1695
69	Hesperia	1861,	April	29	Schiaparelli	1893
70	Panopea	1861,	May	5	Goldschmidt	1542
71	Niobe	1861,	August	13	Luther	1671
72	Feronia	1861,	May	29	Peters and Safford.	1245
73	Clytie	1862,	April	7	Tuttle	1590
74	Galatea	1862,	August	29	Tempel	1691
75	Eurydice	1862,	Sept.	22	Peters	1594
76	Freia	1862,	October	21	d'Arrest.	2080
77	Frigga	1862,	Nov.	12	Peters	1596
78	Diana	1863,	March	15	Luther	1554
79	Eurynome	1863,	Sept.	14	Watson	1399
80	Sappho	1864,	May	2	Pogson	1270
81	Terpsichore	1864,	Sept.	30	Tempel	1693
82	Alcmene	1864,	Nov.	27	Luther	1659
83	Beatrix	1865,	April	26	Gasparis	1381
84	Clio	1865,	August	26	Luther	1330
85	Io	1865,	Sept.	19	Peters	1583
86	Semele	1866,	January	4	Tietjen	1983
87	Sylvia	1866,	May	16	Pogson	2384
88	Thisbe	1866,	June	15	Peters	1675
89	Julia	1866,	August	6	Stephan	1472
90	Antiope	1866,	October	11	Luther	2031
91	Ægina	1866,	Nov.	4	Stephan	1495
92	Undina	1867,	July	7	Peters	2086
93	Minerva	1867,	August	24	Watson	1669
94	Aurora	1867,	Sept.	6	Watson	2050
95	Arethusa	1867,	Nov.	23	Luther	1964
96	Ægle	1868,	February	17	Coggia	1950
97	Clotho	1868,	February	17	Tempel	1592
98	Fanthe	1868,	April	18	Peters	1607
99		1868,	May	28	Borelly	....
100	Hecate	1868,	July	11	Watson	1892
101	Helena	1868,	August	15	Watson	1508
102	Miriam	1868,	August	22	Peters	1587
103		1868,	Sept.	7	Watson	1622
104		1868,	Sept.	13	Watson	2071
105		1868,	Sept.	16	Watson	1341
106		1868,	October	10	Watson	2092
107	Camilla	1868,	Nov.	17	Pogson	....
108	Hecuba	1869,	April	2	Luther	2081
109		1869,	Oct.		Peters	

* Goldschmidt at first believed it to be *Daphne* (41), but Schubert finding its period different, called it *Pseudo-Daphne*. It was not seen from 1857 to 1861, when *Luther* rediscovered it, and named it *Melete*.

The numerical order is that adopted by the authority of the Berlin Ephemeris.

SIMPLE DIRECTIONS

TO A BEGINNER

FOR

PERFORMING THE EXPERIMENTS

IN THE

FOURTEEN WEEKS' COURSE

IN

CHEMISTRY.

[The large figures refer to the page of the Chemistry, and the small ones to the number of the experiment. Read for additional directions, Chemistry, pp. 235-248.]

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9. 1. Put as much chlorate of potash (potassic chlorate) as will lie upon the point of a knife-blade, and half as much sulphur, into the mortar. Grind them slowly with the pestle until the ingredients are thoroughly mixed and distributed over the bottom of the mortar. Hold the mortar so that the loose particles cannot fly into your eyes, nor the flame burn your clothes, and then grind heavily with the pestle, when rapid detonations will ensue. The mixture will last for days. After use, clean out the mortar carefully for other experiments. The powder can be wrapped with paper into a hard pellet and exploded on an anvil by a sharp blow from a hammer. Sometimes small bits of phosphorus are used instead of sulphur. Great care is then necessary, as the particles of burning phosphorus are apt to fly to some distance.

10. 1. Two teaspoonfuls of common carbonate of soda and one of tartaric acid should be dissolved separately in a wine-glass of water. On being poured together in a larger glass, they will violently effervesce. Use a glass large enough to prevent any running over upon the table. Neatness in experiments is essential to perfection, and often to success.

13. 1. The cabbage solution is made by steeping purple cabbage leaves in water. A little lemon-juice or vinegar will turn it to a bright red, and a little of the potash solution to a deep green. Add a little alcohol to the red solution, to keep it from freezing, and bottle it for use. Dissolve a little of the dry litmus in water, filter and bottle it. These are to be used in testing the alkalies and acids. Dissolve also a stick of the potash in water, filter and bottle. Fill two test-tubes nearly full of water; color one with the cabbage and the other with the litmus solution. Add a few drops of the potash solution and of the sulphuric acid alternately to each. The color can be changed at pleasure.

Take a small bit of tubing, and heating the ends in the flame of the spirit-lamp (the greatest heat is near the tip of the flame), seal up the opening. This will be useful to dip into the acid or alkali, as it will remove a drop more readily than by dropping from the bottle.

18. Pulverize an ounce of the potassic chlorate very carefully; stir in it one-fourth of its weight of the black oxyd of manganese and place the mixture in the copper retort, attach the tubing and gas-bag as shown in the figure of p. 234; or in the Florence flask, attaching a delivery tube, as shown in figure on p. 18. The glass tubing may be heated in the flame of the alcohol-lamp and bent to the desired shape, or it can be broken into short lengths by simply starting the break in the tube by a mere scratch with a three-cornered file and then connecting the pieces of glass tubing with a short bit of the small rubber tubing, as in the figure on p. 18. The gas may be passed off from the gas-bag, or directly from the retort into the pneumatic cistern, C, across which is placed a shelf perforated, to permit the gas to bubble up into the receiver, J. The pneumatic cistern may consist of a tub of water. The bottles for collecting the gas are sunk into the water until filled, inverted, and then lifted up on the shelf, carefully keeping the lower edge of the bottle beneath the water. A large tin pan, without any shelf, may be used as a cistern by filling the bottles full of water in a deep pail, and then slipping a plate underneath each one, as shown in the second figure on p. 20, leaving enough water on the plate to cover the edge of the bottle; it may then be lifted out and placed in the cistern. In the same way the bottles, when filled with gas, may be removed and kept for use. Gas may be passed from one bottle to another by inverting one over the other beneath the water in the pneumatic cistern, or in a large pail, when the gas will bubble up from the lower one into the upper one.

Apply the heat to the glass retort very carefully at first, holding the lamp in the hand and moving it around so that the flame may strike all the lower part of the flask, and thus expand it uniformly. Be careful also that there is no draft of cold air to strike against the heated retort. With the copper retort no care of this kind is necessary. When the gas ceases to come off, remove the stopper or lift the end of the tube out of the water; otherwise, as the retort cools and a vacuum is formed, the water in the cistern will set back into the flask, and, if of glass, will break it. An ounce of the salt will make over six quarts of oxygen gas. When the retort is partly cooled, pour in some *warm* water to dissolve the residuum, which may then be poured out and the retort drained and set away for future use. In order to test the purity of the materials, and thus avoid any danger of an explosion, place a little of the mixture for making oxygen in an iron spoon and heat it over the spirit-lamp. If the gas passes off quietly, no danger need be apprehended.

20. 1. The experiment with the candle can be performed most strikingly by filling a common fruit-jar with nitrogen (see page 30) and another with oxygen. The covers will preserve the gases until wanted for use. The covers may then be laid loosely on top of the jars, and the lighted candle passed quickly from one jar to the other. It will be extinguished in one and relighted in the other. With care, it may be passed and repassed a dozen times. This strikingly illustrates the difference between oxygen and nitrogen. Test the carbonic acid, in this as in all similar experiments, with the blue litmus and the green cabbage, or a slip of blotting-paper wet with the litmus solution. A few drops of the solution may be poured into the jar, and then the jar shaken, so as to permit the water to absorb the gas. The candle may be simply stuck upon the end of a bent wire, but it is much neater to have the tinsmith fit a little cup for its reception, as shown in the figure.

2. The worn-out watch-springs which can be obtained gratis of any jeweller, may be easily straightened by drawing them between the fingers. If the end of each spring be heated and then pounded with a hammer on any smooth hard surface, the temper may be thoroughly drawn and the edge sharpened. Make a slit with a knife in the side of a match, into which insert the edge of the spring. Take a piece of zinc or tin large enough to cover the mouth of the jar containing the oxygen, and make a hole through it with a nail. Pass the other end of the spring through this hole, and then through a thin cork. The spring is now ready for burning. The metal cover will prevent the flame from coming out of the jar and burning one's hand, and the cork will hold the spring in its place. When the match is ignited, and then lowered into the jar of oxygen, the spring should not reach more than half-way to the bottom, and should be pushed down as it burns. If a specie-jar be used, do not fill it quite full of gas, as a little water left in the bottom will prevent the melted globules of iron from breaking the glass.

21. 1. If brimstone be used in this experiment, and it fails to light readily, pour upon it a few drops of alcohol, and then ignite it.

2. If you have not a deflagrating spoon to contain the phosphorus, one may be readily extemporized. Hollow a small piece of chalk and attach it to a wire, which may then be secured to a metal top, as in the case of the watch-spring. This need *not* be pushed down into the jar as the burning progresses. At the close of the experiment, test for the acid formed in the combustion. The fumes are very disagreeable, and should not be inhaled or allowed to escape into the room.

3. If a piece of *bark* charcoal be ignited, and then lowered into a jar of oxygen, it will deflagrate with bright scintillations.

22. 1. Put in an evaporating-dish a little starch; cover it with water in which a few crystals of iodide of potassium have been dissolved, and heat. Stir the liquid, to prevent lumps. When cooked, immerse in the paste slips of blotting-paper. Use while moist. Be careful not to heat the glass tube too hot, lest the ether vapor may ignite. Keep the jar well filled with vapor by frequently shaking it. Lower into the ozone a bit of silver-leaf moistened with water; it will quickly crumble into dust, the oxyd of silver.

32. 1. To make the iodide of nitrogen, cover a few scales of iodine with strong aqua ammonia. After standing for a half-hour, pour off the liquid and place the brown sediment in small pieces on bits of broken earthenware to dry. This will require several hours. They may then be taken to the class-room very carefully and exploded by a slight touch of a rod, or even a feather.

37. 1. For making NO_5 a special apparatus is necessary for complete success. The Florence flask may, however, be used, and the heat of the spirit-lamp will be sufficient. The fumes may be caught in the evolution flask, which is kept cool by a towel frequently wet. When the retort is partially cooled, at the conclusion of the process, pour in a little warm water, to dissolve the sulphate of potash, otherwise the retort may break by the crystallization of the salt.

2. Mix equal parts of nitric acid and oil of vitriol (perhaps a teaspoonful of each), and pour the mixture on hot finely-powdered charcoal, or on a little oil of turpentine. It will be oxydized with almost explosive violence. This should be performed out of doors.

3. Bits of tin may be obtained of any tinsmith. Put them in a tumbler and nearly cover them with the NO_5. In using copper, the apparatus shown on page 39 is excellent. The acid may be turned in gradually through the funnel tube. Before putting in the acid pour into the flask warm water to cover the lower end of the funnel tube, which should nearly reach the bottom of the flask. When a jar is filled with the NO_2 it may be lifted out of the water and inverted, when the NO_4 will pass off in blood-red clouds. If the jar be left in the cistern and one edge be lifted so as to admit a bubble of air, red fumes will fill the jar. By standing a moment the

water will absorb the red vapor. This process can be repeated several times with the remaining gas.

40. 1. The finely-powdered sal-ammoniac and lime may be mixed in an evaporating-dish. The escaping ammonia should be tested with a glass rod or tube wet with hydrochloric acid.

2. Heat a little aqua ammonia in the Florence flask. Collect the vapor in an inverted bottle, to which is fitted a cork and tube, with the inner extremity drawn to a fine point over the spirit-lamp. Insert the cork, and then plunge the bottle into a vessel of water. The water which passes in first will absorb the gas so quickly as to make a partial vacuum, into which the water will rush so violently as to produce a miniature fountain.

42. 1. In making H, the directions given on pages 236–7 should be carefully observed. For purifying the gas a solution of potash should be placed in the flask *d* (page 42). If a junk bottle be used the acid should be added slowly, as the heat generated is liable to break the bottle. Pour the water into the flask *a* until the lower end of the funnel is covered, before adding the acid. The flow of gas may be regulated by additions of acid, as may be wanted. One part of acid to ten or twelve of water will liberate the gas very rapidly. If it comes off very fast, the liquid is liable to froth over. The philosopher's lamp, page 237, is very interesting. The jet may be a straight glass tube drawn to a fine point over the spirit-lamp. Large glass tubes or the beaks of broken retorts, held over this flame, will produce the singing tones, though not as well as the apparatus figured in the book. The tone may be regulated by the size of the flame, *i. e.* the rapidity with which the gas comes off, the size of the jet as well as the length and size of the tubes. The H can be collected over the pneumatic cistern, or, since it is lighter than air, in inverted bottles. As soon as the bottles are turned right side up the gas will escape. To measure the H and O for the "mixed gases," a receiver, with a stop-cock on top, which may be connected by rubber tubing with the gas-bag, is very useful. The oxygen may be passed directly into the gas-bag, however, as on page 234, until it is about one-third full, when the bag may be removed and attached to the hydrogen apparatus to be filled.

50. 1. In lieu of a small crucible, fill a common tobacco-pipe with crystals of blue vitriol, and heat them over the lamp or in a common fire until the water of crystallization is expelled. Alum may be rendered anhydrous in the same manner.

56. 1. Small paste-diamonds may be obtained of a jeweller, to illustrate the forms of cutting the diamond.

60. 1. Place a filtering paper in the glass funnel, and in it a couple of ounces of bone-black or finely-powdered charcoal. Filter through it water colored with ink, litmus, or any other impurities. In pouring the liquid into the filter hold a glass rod against the edge of the pouring vessel, so as to direct the stream into the funnel. The funnel may be placed in the nozzle of a bottle, but must not fit closely. A bit of wood or a thread inserted between the stem of the funnel and the nozzle will leave an opening sufficient for the egress of the air.

64. 1. Break some marble into small bits; place them carefully in the evolution-flask, and, inserting the cork and tube, pour in HCl slowly. The gas, on account of its weight, may be passed directly into a bottle or jar.

2. Lower a lighted candle into a jar of the gas, or, lowering the candle into an empty jar, pour the gas into the jar, as if it were water. Test the acid with litmus paper.

3. Place a piece of lime as large as an egg in a pint of water; let it stand overnight; pour off the clear liquid—it is lime-water. Place a little in a tumbler and breathe through it by means of a tube, or pass a current of CO_2 from the evolution-flask until the liquid, at first milky, clears.

4. Breathe through a tube into an empty bottle. Lower into it a lighted candle—it will be immediately extinguished. Pour in some lime-water, shake it thoroughly and it will become milky.

5. Twist a wire around the neck of a small wide-mouthed vial, to answer as a bucket. Lower it by the wire into a jar of CO_2, our ideal well foul with the gas. Raise it again, and test for the CO_2 by means of a lighted match. The bucket will be found to be full of the gas.

6. Fill a jar with hydrogen, and in a similar way dip the gas *downward* and burn it over a lamp. This shows in a very striking manner the difference between H and CO_2 in respect to specific gravity. The one, we see, is dipped upward, the other downward.

7. Balance a large paper bag or box on a delicate pair of scales, or in any simple manner one's ingenuity may suggest. Empty into the box a large jar of CO_2, and the box will quickly descend.

8. Arrange little wax-tapers in a wooden or pasteboard trough, as on page 65. Light them, and then pour in at the top a bottle of carbonic acid gas. If the proper slant is given to the trough, all the candles will be extinguished.

72. 1. Olefiant gas may be made by heating in the flask one part, by measure, of alcohol and two parts of sulphuric acid. Pass it through a solution of potash, as shown on page 88, and then collect in the gas-bag. Fit a piece of glass tubing, drawn to a fine point at one end, to the stop-cock of the gas-bag by means of a bit of the rubber tubing. On turning the stop-cock and forcing out the gas it may be ignited, when it will burn with a clear white light.

2. Fill a tall jar one-third full of olefiant gas, and the remainder with chlorine gas. On lighting, the mixture will burn with a dense cloud of smoke. HCl is the product of the combustion.

3. Mix with oxygen and explode in soap-bubbles. It produces a greater noise even than the "mixed gases." Great care must be taken not to let the light approach the gas-bag containing the mixture.

4. Fit a large test-tube with a cork and a piece of glass tubing, drawn to a fine point at the outer end. Fill the tub with fine dry pine-shavings. On heating, the gases from the wood will pass off, and can be ignited at the jet-tube. The test-tube can be held by a strip of twisted paper or wire.

5. At the close of the 1st exp. perform the one figured on page 79. A small piece of wire-gauze, 4 or 6 inches square, for this purpose can be purchased of any tinsmith. If you do not force the gas out too rapidly, you will be able to burn it on either side of the gauze at pleasure.

70. Place on top of the gauze a bit of camphor-gum. Ignite it, and the flame will not pass through to the lower side. Then ignite on the lower side, and extinguish the flame on the upper side.

77. The carbonic acid of a burning candle may be passed through lime-water in the following manner. Take a bottle arranged with tubes, as in the middle one shown in the figure on page 87. From the tall tube at the left suspend a glass funnel with the stem coupled to the tube by means of a piece of rubber tubing. Place under this funnel a burning candle. Partly fill the bottle with lime-water. Then placing the mouth to the right-hand tube, draw out the air from the bottle. This makes a draft over the candle, and draws its invisible smoke through the funnel, down the long tube, and up through the lime-water, which soon becomes milky.

80. The compound blow-pipe with gasometers, as shown on page 238, is the most serviceable. If gas-bags are used, the one for hydrogen should be twice the size of the one for oxygen. A board should be laid on each bag, upon which weights may be placed, when ready for use, so as to force out the gas steadily. Turn the stop-cock so that the H will pass out twice as fast as the O. Always ignite the H first, and then turn on the O slowly until the best effect is produced. If gasometers are used, press the inner receivers down to the bottom, and then pour in water till it reaches nearly the top. The rubber pipes may then be attached to the hydrogen or oxygen apparatus, and the gases passed directly into the gasometers. Proper pressure is produced, when the jet is to be ignited, by unloosing the strings from the inner receivers, and thus taking off the "lift" of the weights which equipoise them. Additional pressure is secured by bearing down upon the receivers. All the metals burn in the blow-pipe flame with their characteristic colors. Narrow slips should be prepared for this purpose. A mirror, and a cup for holding the chalk, are necessary to show the lime-light. A piece of hard chalk or lime, whittled to about the size of a pencil, may be held in the flame to illustrate the principle.

87. Put in the flask two ounces of common salt and an ounce and a half of black oxyd of manganese. Pour on enough water to reduce the mixture to a thin liquid. Shake the flask until the whole interior is moistened. Insert the cork and delivery-tube; the middle bottle shown in the figure is not necessary. Fill the pneumatic cistern with *warm water, using just as small a quantity as possible,* since water absorbs the gas. Pour in an ounce of the oil of vitriol through the funnel-tube, or directly at the nozzle, by removing the ground stopper, if a kind of flask be used which has one. The gas will come off at once, even before the heat is applied. Collect the gas in bottles and use directly, if convenient, otherwise put corks in them and rub the nozzles well with tallow. Pass the gas through cold water, as shown on page 88, or more simply, through a tumbler of water. This will form chlorine water, which should be bottled and kept in a dark place.

2. Fill a test-tube nearly full of pure rain or snow water, and let fall into it a drop or two of the nitrate of silver solution. A drop of HCl will form a cloudy white precipitate.

91. 1. Place on a clean white dish a few scales of iodine and a bit of phosphorus as large as a pea. It will soon ignite.

2. Fill three test-tubes nearly full of soft water. Pour in one a few drops of a solution of bichloride of mercury, into the second of sugar of lead, into the third of subnitrate of mercury (formed by pouring NO_5 on mercury). Add to each of these a few drops of the solution of iodide of potassium. The first especially will produce a brilliant color (iodide of mercury); the rapid change from yellow to red is very marked. On continuing to add the iodide of potassium, the red precipitate will be dissolved and disappear.

3. Make an additional quantity of the iodide of mercury, as in the 2d exp. Let it settle. Pour off the liquid, and then spread the sediment on a piece of heavy card-board, making a red spot as large as a silver dollar. Dry it carefully. Then heat very strongly, when it will turn yellow. Rub over the yellow spot the point of a knife several times, bearing on very firmly, and a red mark can be seen. Lay away the paper for a day or two, and the red color will spread over the whole spot.

4. Dissolve a few scales of iodine in fifteen or twenty times its bulk of alcohol. Pour a few drops of this solution on a

freshly-cut potato or apple. Blue specks will show the presence of starch.

96. 1. Melt a quantity of sulphur, either the flowers or brimstone, in a test-tube. It is at first thick and dark-colored, but after continued heating becomes thin and dark-colored. Pour it now into water and it will form an elastic gum, which can be moulded into any desired form.

2. Heat a piece of brimstone in a test-tube. After a little the sulphur will sublime and collect in the upper part of the tube as flowers of sulphur.

3. Fill a cup with brimstone and melt it with a gentle heat. Set it aside to cool. When a crust has formed on top, break it and pour out the liquid contents. If the cup be broken, the bottom will be found covered with crystals of sulphur.

100. Place in the evolution-flask half an ounce of sulphuret of iron. Cover this with water, and then pour in oil of vitriol through the funnel until the gas comes off freely. It may be passed through a glass of cold water. This solution must be bottled and closely corked. The gas may be tested directly; see page 137.

102. 1. Cover a stick of phosphorus with dry, fine-powdered charcoal. It will soon ignite.

2. Put in a vial half an ounce of sulphuric ether and a half-dozen pieces of phosphorus not larger than grains of wheat. Thoroughly shake and then set away. Repeat the shaking often. When the phosphorus is dissolved, pour a little of the solution on the hands, and when briskly rubbed together in a dark place they will glow with a ghostly light.

3. Pour some of the solution on a lump of loaf-sugar. Drop this in hot water, when the ether will catch fire.

4. Place in a wine-glass a few crystals of chlorate of potash and a small bit of phosphorus. Fill the glass nearly full of water. By means of a funnel-tube, pour a little oil of vitriol to the bottom of the glass. A violent deflagration will immediately take place, and, in a dark room, flashes of green light will be seen.

119. Cut off three or four inches of magnesium ribbon, and holding one end with a pair of pincers, thrust the other into the flame of the spirit-lamp. The metal will almost instantly ignite, when it may be removed and held up to the view of the class until the Mg is consumed.

133. To make a saturated solution of alum, drop crystals of the salt into boiling water, until a drop of the liquid taken out on the end of a glass rod and put on a bit of glass will crystallize as soon as it cools.

134. Fill a test-tube nearly full of water. Pour in it a few drops of the solution of sulphate of copper. Add ammonia, and a blue precipitate will be formed. Notice the change from green to blue. The sulphate of copper may be readily made for this experiment by covering a copper cent with dilute oil of vitriol. This experiment may be made to show the divisibility of matter by weighing the cent, then seeing what proportion of the whole solution you use, and then experiment to find what quantity of water can be taken and yet have the blue color perceptible in the ammonia test.

135. Fill a test-tube one-sixth full of sweet oil, add a little ammonia, and nearly fill with water. The constituents remain separate. Shake thoroughly, and they will combine, forming a thin, soapy liquid. Add an acid, and they will dissolve partnership at once.

SUGGESTIONS.

Melted snow, or very clear rain-water, will answer the place of distilled water in making solutions, &c., for experiments. Whenever corks leak gas they may be wrapped with thin strips of wet paper to make them fit more tightly, or the entire nozzle may be smeared with tallow, or covered with sealing-wax, if heat is not used. In that case a little plaster of paris may be wet up and quickly applied. The experimenter will find a retort-stand for holding the retorts, a test-tube holder, a set of tin cork-borers, several Florence flasks of different sizes, the copper retort for making oxygen, and the gas-bag, with its tubing and connectors, almost indispensable. After these, the compound blow-pipe is of the greatest value. A few drops of a solution of magenta (¼ dr. in a gill of HO) will color the water beautifully, and add to the effect of certain experiments.

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I traveled two years amusing myself in instructing (exclusively) Grammar classes with Clark's system. The first class I instructed fifty days, but found that this was more time than was required to impart a theoretical knowledge of the science. During the two years thereafter I instructed classes only *thirty* days each. Invariably I proposed that unless I prepared my classes for a more thorough, minute, and accurate knowledge of English Grammar than that obtained from the ordinary books and in the ordinary way in from one to two years, I would make no charge. I never failed in a solitary case to far exceed the hopes of my classes, and made money and character rapidly as an instructor.

From A. B. Douglass, *School Commissioner, Delaware County, New York.*

I have never known a class pursue the study of it under a *live* teacher, that has not succeeded; I have never known it to have an opponent in an educated teacher who had *thoroughly* investigated it; I have never known an *ignorant* teacher to examine it; I have never known a teacher who has used it, to try any other.

From J. A. Dodge, *Teacher and Lecturer on English Grammar, Kentucky.*

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From W. T. Chapman, *Superintendent Public Schools, Wellington, Ohio.*

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☞ For further testimony of equal force, see the Publishers' Special Circular, or current numbers of the Educational Bulletin.

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The Peabody Correspondence.

NEW YORK, *April* 29, 1867.

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BOSTON, *May* 7, 1867

MESSRS. A. S. BARNES & CO., PUBLISHERS, NEW YORK:

GENTLEMEN—Your communication of the 29th ult., addressed to the Trustees of the Peabody Education Fund, has been handed to me by our general agent, the Rev. Dr. Sears. I shall take the greatest pleasure in laying it before the board at their earliest meeting. I am unwilling, however, to postpone its acknowledgment so long, and hasten to assure you of the high value which I place upon your gift. Five thousand volumes of your "Teachers' Library," and twenty-five thousand volumes of "School-Books for intermediate classes," make up a most munificent contribution to the cause of Southern education in which we are engaged. Dr. Sears is well acquainted with the books you have so generously offered us, and unites with me in the highest appreciation of the gift. You will be glad to know, too, that your letter reached us in season to be communicated to Mr. Peabody, before he embarked for England on the 1st instant, and that he expressed the greatest gratification and gratitude on hearing what you had offered.

Believe me, gentlemen, with the highest respect and regard, your obliged and obedient servant, ROBT. C. WINTHROP, Chairman.

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