4. Three whaleboats tow a buoy in directions E., N.W., and W. 30° S. respectively, at speeds of 4, 5, and 3 miles an hour: find the compass course of the buoy, and its position at the end of ten minutes.

5. The triangle formed by drawing lines from two adjacent corners to the centre of a regular pentagon of homogeneous cardboard is cut out: find the position of the centre of gravity of the remainder of the pentagon.

6. On two inclined planes of equal height h and of lengths a and b two carriages of weights P and Q are supported by a string passing over a frictionless pulley at the common vertex: find the acceleration, if any; and find the ratio of P to Q when there is equilibrium.

7. What is the mechanical advantage in a common screw press, when the screw has a pitch of $\frac{1}{8}$ inch and is turned by a lever 3 feet long?

8. A circular homogeneous table-top 5 feet in diameter and weighing 16 lb. rests on three points of support placed 2 feet apart at the angles of an equilateral triangle having the same centre as the table-top. What is the least weight that will just make the table-top tilt, and at what point must it be applied?

9. Show how to find the specific gravity of a mixture of two substances of given weights and specific gravities.

A substance whose specific gravity is 0·8 is dissolved in six times its own weight of water, and the specific gravity of the solution is found to be 1·025. Find the ratio in which the total volume has been reduced.

10. A cylindrical vessel having an inside diameter of 10 inches is filled with water. In what ratio must the height of the cylinder be divided into two parts, so that the total internal pressures on the upper and the lower parts of the curved surface may be equal? What must be the height of the cylinder, that the pressure on each of the parts may be equal to the pressure on the base?

11. A uniform glass tube 50 cm. long and closed at one end and containing 40 cm. of mercury is inverted and supported in a vertical position in a vessel of mercury. Find the volume of the air within the tube in these three cases:—

(*a.*) When the mouth of the tube is just immersed and the temperature is 10° C.

(*b.*) When the mouth of the tube is 25 cm. below the surface and the temperature is 10° C.

(*c.*) When the mouth of the tube is 25 cm. below the surface and the temperature is raised to 20° C.

Physics.—For Class D. Time allowed: Three hours.

1. Given a thermometer with no divisions on the stem, how would you proceed to provide it with the necessary graduation?

2. In what ways may the evaporation of a liquid be facilitated? Give reasons.

3. Define the term "specific heat," and explain how the specific heat of a substance may be measured by means of an ice calorimeter.

4. A vibrating tuning-fork when held over a narrow glass jar 7 inches in height causes resonance of the air in the jar. Explain this, and find the wave length of the sound emitted by the fork, and the number of vibrations which it makes in a second.

5. Describe some method by which the relative luminosity of two sources of light may be determined. What difficulties, if any, have you observed in making such comparisons?

6. Make a sketch showing the path of the rays of light emitted by a small luminous object and reflected from a concave mirror so placed that the object is between the focus and the centre of curvature of the mirror.

7. In making experiments with a gold-leaf electroscope it is essential that the metallic conductor carrying the gold leaves should be well insulated. What, in your opinion, is the best way of establishing this insulation? Explain the significance of Faraday's ice-pail experiment.

8. What is meant by the "polarisation" of a galvanic cell? Explain how this defect in an ordinary "copper-zinc-sulphuric acid" cell is largely avoided in the Grove cell and in the Leclanché cell.

Sound, Light, and Heat.—For Civil Service Junior. Time allowed: Three hours.

[A candidate may not answer questions from both sections of the paper. All answers should be illustrated, where possible, by diagrams.]

A.—Sound and Light.

1. Explain clearly how sound waves are originated by a vibrating tuning-fork, and how they are propagated through the air. What experimental illustrations tend to throw light on this matter?

2. Would you expect a sound to be conveyed through the air at the top of a mountain with the same velocity as on the plain below? Give reasons for your answer.

3. Why is it that a vibrating tuning-fork held over the mouth of a glass jar causes resonance only when the jar is of a particular height? If, with a given tuning-fork, the proper height of the jar is found to be 11 inches, what will be the vibration number of the fork?

4. How do you account for the fact that a total eclipse of the sun is visible over only a very limited portion of the earth's surface?

5. Show that when a ray of light falls upon a plane mirror, and the mirror is rotated through an angle α, the reflected ray moves through an angle 2α. What physical measurements are made by observation of this movement of the reflected ray?

6. How would you proceed to determine the radius of curvature of a given concave mirror?

7. Make a sketch showing the passage of the rays of light through a convex lens used as a simple microscope, with the eye near the lens.

8. Describe the arrangement of apparatus required in order to throw a spectrum on to a screen.