Mechanics.—For Class D, and for Senior Civil Service. Time allowed: 3 hours. [*Optional.*]

1. Define the units of velocity and acceleration.

If a train is moving at the rate of thirty miles an hour, how many units of velocity has it? And if it attained this velocity in 2 minutes, what was the average acceleration?

2. Explain the distinction between a foot-pound and a foot-poundal.

A cannon-ball of 100lb. weight is moving with a velocity of 1,200ft. per second: find in foot-pounds the work it is capable of performing.

3. Describe Atwood's machine, and explain the principle on which the use of the machine is founded.

4. State and prove the "triangle of forces."

Two forces, equal to the weight of 10lb. and 24lb. respectively, act on a particle in directions at right angles to one another: find the magnitude of the single force which will maintain equilibrium.

5. Show how to find the resultant of two parallel forces which act in the same direction.

6. Weights of 16lb. and 40lb. are suspended from the extremities of a straight uniform lever 12ft. long, and weighing 8lb.: find the position of the fulcrum about which the whole will balance.

7. Find the relation of the power to the weight in the inclined plane, when the power acts horizontally.

What force, acting horizontally, will keep in equilibrium a weight of 30lb. on an inclined plane, and produce a pressure of 34lb. weight on the plane?

8. Define a fluid. What is the distinction between the two kinds of fluids? Explain how the pressure at a point in the fluid is measured.

9. State the conditions of equilibrium of a floating body.

An iceberg floats with nine-tenths of its volume immersed. If the specific gravity of the surrounding salt water be 1·023, what is the specific gravity of the ice?

10. Describe and explain the action of the common suction-pump.

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Physics.—For Class D, and for Junior and Senior Civil Service. Time allowed: 3 hours. [*Optional.*]

1. Explain how you would verify the "fixed points" in a mercury thermometer, stating the precautions which you would take to insure accuracy.

Express the temperatures 100° F. and −100° F. in the Centigrade scale.

2. Define the coëfficient of linear expansion. What are the relations which the coëfficients of superficial and cubical expansion bear to that of linear expansion in the same substance?

If a telegraph wire expands 15in. per mile with an increase of temperature of 20° C., what is its coëfficient of linear expansion?

3. State the laws of fusion. By whom, and in what manner, was the latent heat of fusion of ice first determined? What becomes of the heat which disappears, or becomes latent, during fusion?

4. Explain the following terms as used in the theory of sound: *Wave-length, pitch, musical interval, octave, major third, harmonic.* What is the relation between the length of a stopped pipe and the wave-length of its fundamental note?

Find approximately the pitch of the fundamental note emitted by an open organ-pipe 16in. long.

5. What is meant by the focal length of a lens? What is the distinction between a real and a virtual focus? How would you determine practically the focal length of a double-convex lens?

A candle-flame is placed at the distance of 16in. from a double-convex lens of 1ft. focal length: at what distance on the other side of the lens must a screen be placed to receive a well-defined image of the flame? And what is the size of the image relatively to the flame?

6. Describe, with the aid of a diagram, the optical construction of a compound microscope.

7. Describe the electrophorus, and explain the principle of its action.

8. What is meant by connecting voltaic cells "in series," and "in parallel"? In what circumstances would the latter arrangement be preferable?

A Grove's cell has an E.M.F. of 1·92 volts, and an internal resistance of ·2 ohm. Find the current which three such cells, joined in series, will give through an external resistance of 11·4 ohms.

9. Describe some form of voltameter, and explain the purposes for which it may be used.

Chemistry.—For Class D, and for Junior and Senior Civil Service. Time allowed: 3 hours. [*Optional.*]

1. How would you separate and collect, say, half a litre of pure nitrogen from atmospheric air?

2. Explain fully how you would prepare and collect hydrogen from (*a*) water, (*b*) dilute sulphuric acid.

3. Given saltpetre, common salt, and sulphuric acid, how would you make (*a*) nitric acid, (*b*) hydrochloric acid, (*c*) aqua regia? Give the equations, and describe the apparatus required.

4. Explain (giving the equations) how you would made phosphoretted hydrogen from phosphorus; and show what changes take place when that gas burns.

5. Required half a litre of each of the following gases—*nitrous oxide, nitric oxide, ammonia, chlorine*—show clearly how you would make and collect them.