Name:

Date:

THERMAL PHYSICS
TEST 3

A2-Level

Mark

Grade

PHYSICS

For this paper you must have:

- Ruler
- Pencil and Rubber
- Scientific calculator, which you are expected to use when appropriate

Instructions

- Answer all questions
- Answer questions in the space provided
- All working must be shown

Information

- The marks for the questions are shown in brackets

1 In an experiment to measure the temperature of the flame of a Bunsen burner, a lump of copper of mass 0.12 kg is heated in the flame for several minutes. The copper is then transferred quickly to a beaker, of negligible heat capacity, containing 0.45 kg of water, and the temperature rise of the water measured.

specific heat capacity of water = 4200 J kg^{-1} K^{-1}
specific heat capacity of copper = 390 J kg^{-1} K^{-1}

(a) If the temperature of the water rises from 15 °C to 35 °C, calculate the thermal energy gained by the water.

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(2)

(b) (i) State the thermal energy lost by the copper, assuming no heat is lost during its transfer.

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(ii) Calculate the fall in temperature of the copper.

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(iii) Hence calculate the temperature reached by the copper while in the flame.

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(4)

(Total 6 marks)

2 The number of molecules in one cubic metre of air decreases as altitude increases. The table shows how the pressure and temperature of air compare at sea-level and at an altitude of 10 000 m.

altitude	pressure/Pa	temperature/K
sea-level	1.0×10^5	300
10 000 m	2.2×10^4	270

(a) Calculate the number of moles of air in a cubic metre of air at

(i) sea-level,

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(ii) 10 000 m.

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(3)

(b) In air, 23% of the molecules are oxygen molecules. Calculate the number of extra oxygen molecules there are per cubic metre at sea-level compared with a cubic metre of air at an altitude of 10 000 m.

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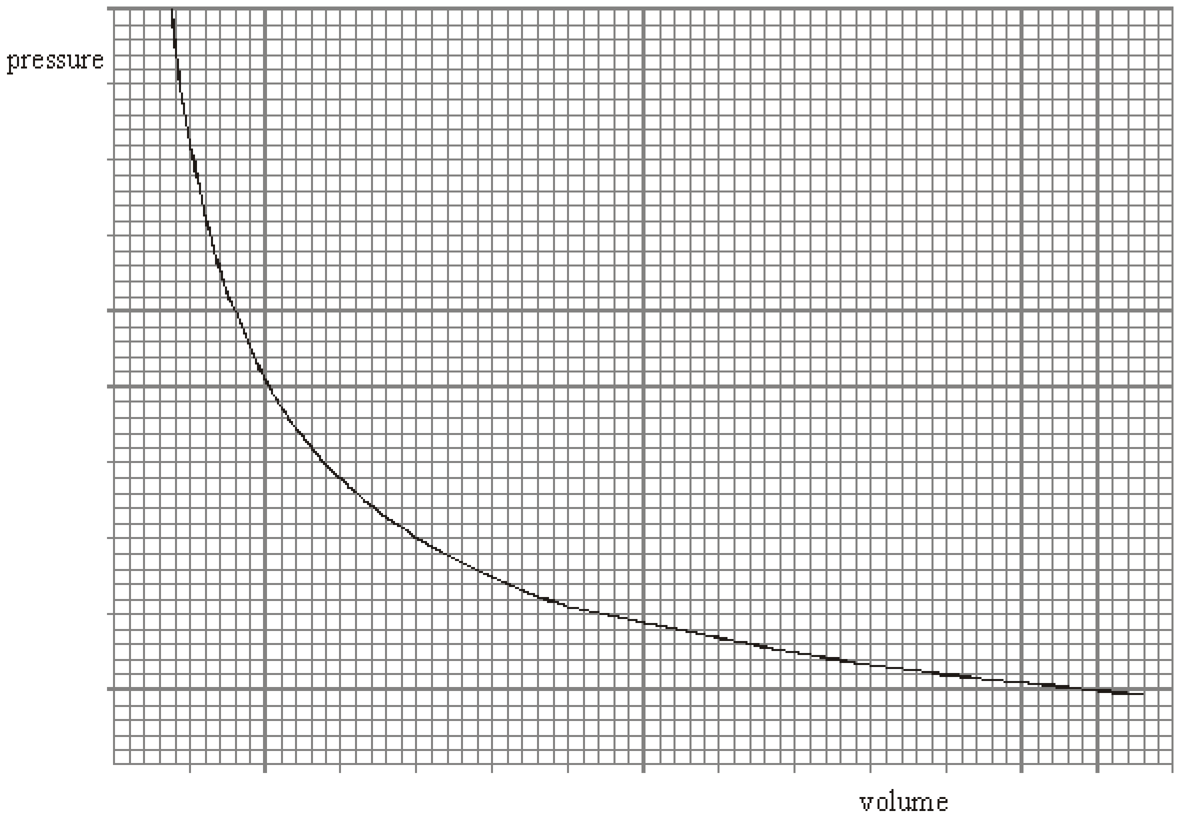
(2)

(Total 5 marks)

3 The graph shows how the pressure of an ideal gas varies with its volume when the mass and temperature of the gas are constant.



(a) On the same axes, sketch **two** additional curves **A** and **B**, if the following changes are made.

(i) The same mass of gas at a lower constant temperature (label this **A**).

(ii) A greater mass of gas at the original constant temperature (label this **B**).

(2)

(b) A cylinder of volume 0.20 m^3 contains an ideal gas at a pressure of 130 kPa and a temperature of 290 K. Calculate

(i) the amount of gas, in moles, in the cylinder,

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(ii) the average kinetic energy of a molecule of gas in the cylinder,

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(iii) the average kinetic energy of the molecules in the cylinder.

(5)
(Total 7 marks)

4 (a) (i) One of the assumptions of the kinetic theory of gases is that molecules make *elastic collisions.* State what is meant by an elastic collision.

(ii) State **two** more assumptions that are made in the kinetic theory of gases.

(3)

(b) One mole of hydrogen at a temperature of 420 K is mixed with one mole of oxygen at 320 K. After a short period of time the mixture is in *thermal equilibrium*.

(i) Explain what happens as the two gases approach and then reach thermal equilibrium.

(ii) Calculate the average kinetic energy of the hydrogen molecules before they are mixed with the oxygen molecules.

(4)
(Total 7 marks)

5 A female runner of mass 60 kg generates thermal energy at a rate of 800 W.

(a) Assuming that she loses no energy to the surroundings and that the average specific heat capacity of her body is 3900 J $kg^{-1}K^{-1}$, calculate

(i) the thermal energy generated in one minute,

(ii) the temperature rise of her body in one minute.

(3)

(b) In practice it is desirable for a runner to maintain a constant temperature. This may be achieved partly by the evaporation of sweat. The runner in part (a) loses energy at a rate of 500 Wby this process.

Calculate the mass of sweat evaporated in one minute.

specific latent heat of vaporisation of water = 2.3×10^6 J kg^{-1}

(3)

(c) Explain why, when she stops running, her temperature is likely to fall.

(2)

(Total 8 marks)

6 An electric shower heats the water flowing through it from 10°C to 42°C when the volume flow rate is 5.2×10^{-5} m^3 s^{-1}.

(a) (i) Calculate the mass of water flowing through the shower each second.

density of water = 1000 kg m^{-3}

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(ii) Calculate the power supplied to the shower, assuming all the electrical energy supplied to it is gained by the water as thermal energy.

specific heat capacity of water = 4200 J kg^{-1} K^{-1}.

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(4)

(b) A jet of water emerges horizontally at a speed of 2.5 m s^{-1} from a hole in the shower head. The hole is 2.0 m above the floor of the shower. Calculate the horizontal distance travelled by this jet. Assume air resistance is negligible.

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(3)

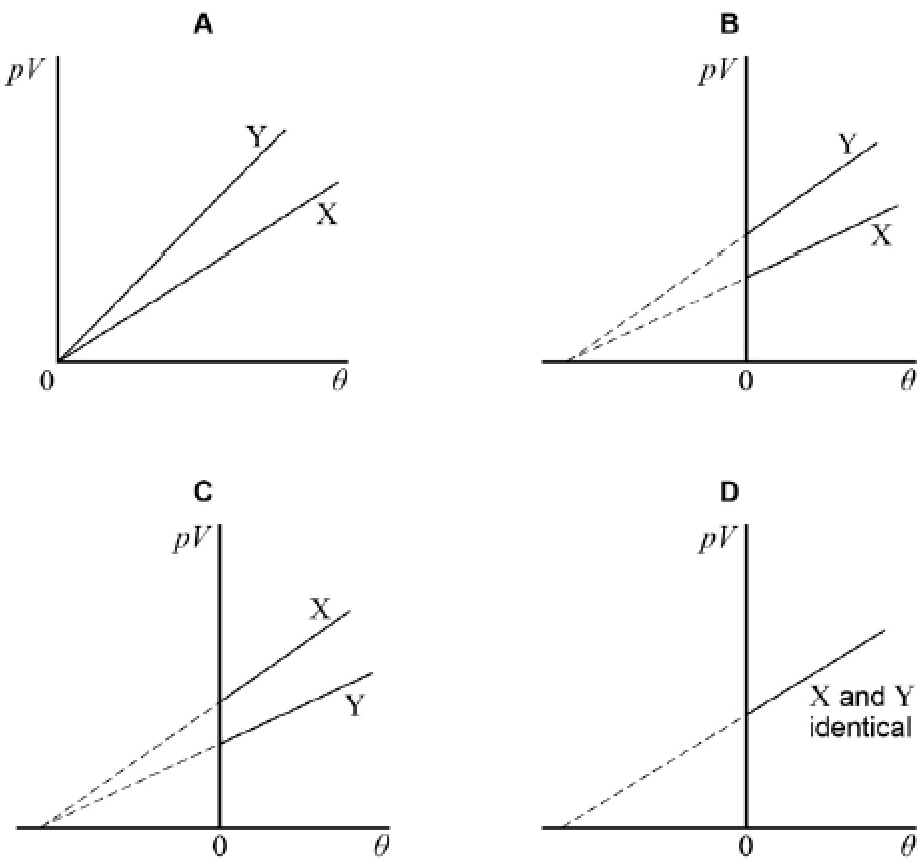
(Total 7 marks)

7 One mole of gas occupies a volume V at a pressure p and Celsius temperature θ.

The graphs, **A** to **D**, show variation of pV with θ.
Line X is for one mole of nitrogen and line Y is for one mole of oxygen.

Relative molecular mass of nitrogen = 28
Relative molecular mass of oxygen = 32

Which graph is correct?



A ○

B ○

C ○

D ○

(Total 1 mark)

8 A liquid flows continuously through a chamber that contains an electric heater. When the steady state is reached, the liquid leaving the chamber is at a higher temperature than the liquid entering the chamber. The difference in temperature is Δt.

Which of the following will increase Δt with no other change?

A Increasing the volume flow rate of the liquid

B Changing the liquid to one with a lower specific heat capacity

C Using a heating element with a higher resistance

D Changing the liquid to one that has a higher density

(Total 1 mark)

9 The temperature of a hot liquid in a container falls at a rate of 2 K per minute just before it begins to solidify. The temperature then remains steady for 20 minutes by which time all the liquid has all solidified.

What is the quantity $\frac{\text{Specific heat capacity of the liquid}}{\text{Specific latent heat of fusion}}$?

A $\frac{1}{40}\,K^{-1}$

B $\frac{1}{10}\,K^{-1}$

C $10\ K^{-1}$

D $40\ K^{-1}$

(Total 1 mark)

10 A fixed mass of gas occupies a volume V. The temperature of the gas increases so that the root mean square velocity of the gas molecules is doubled.
What will the new volume be if the pressure remains constant?

A $\frac{V}{2}$ ⬭

B $\frac{V}{\sqrt{2}}$ ⬭

C $2V$ ⬭

D $4V$ ⬭

(Total 1 mark)