1 In this experiment, you will investigate the phase difference between the oscillations of two mass–spring systems.

(a) • Assemble the apparatus as shown in Fig. 1.1.

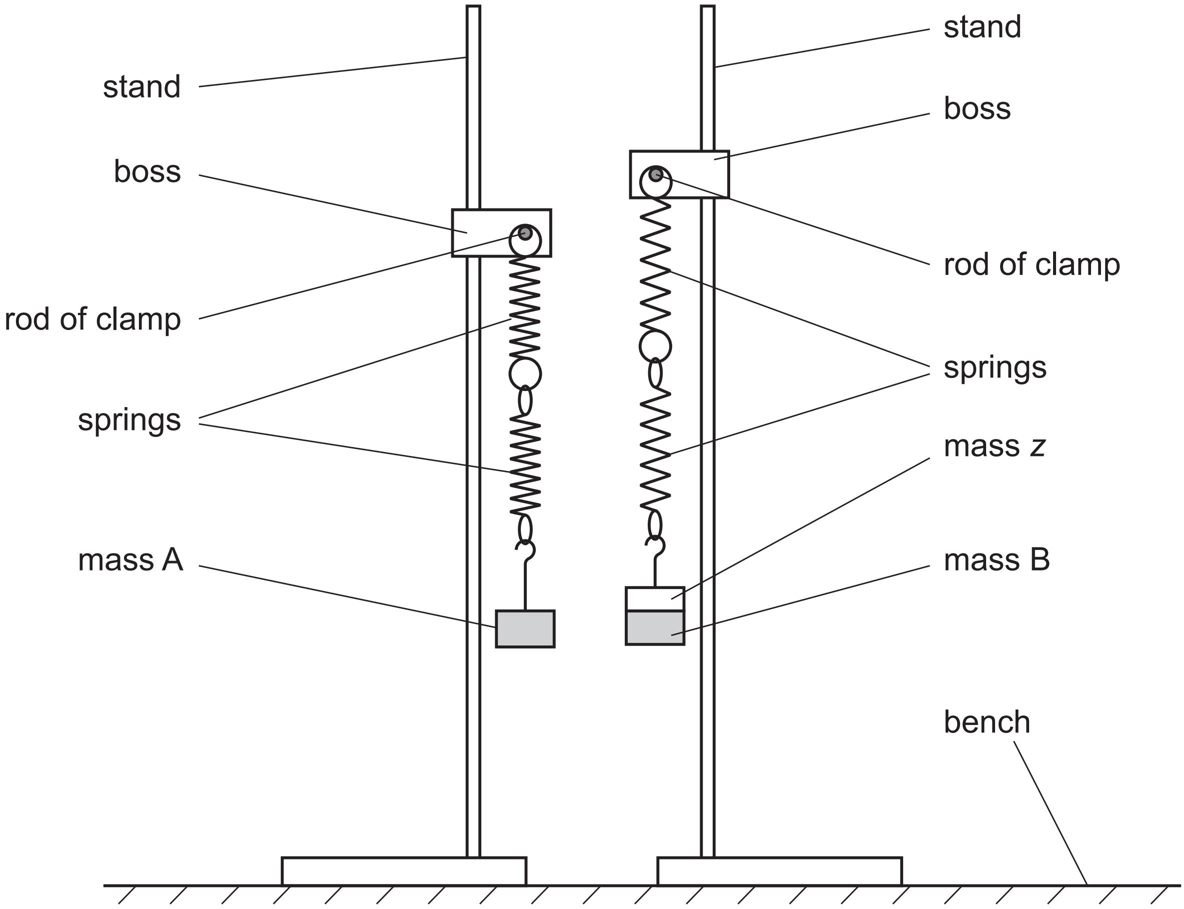

Fig. 1.1

- Mass A and mass B are each 200 g.
- Add a mass z of 40 g to mass B.

  Record the value of z.

z = ... g

- M is given by $M = 200\,\text{g} + z$.

  Calculate M.

M = ... g

- Pull both A and B down a short distance and release them together. Observe the oscillations. A and B initially oscillate in phase (both moving up and down together), then their oscillations go out of phase and then become in phase again.

- The time from A and B oscillating in phase to the next time they oscillate in phase is *P*.

  Measure and record *P*.

P = ...

[2]

(b) Change z and determine P. Repeat until you have six sets of values of z and P.

Record your results in a table. Include values of M, $\frac{1}{\sqrt{M}}$ and $\frac{1}{P}$ in your table.

[10]

(c) **(i)** Plot a graph of $\frac{1}{P}$ on the y-axis against $\frac{1}{\sqrt{M}}$ on the x-axis. [3]

(ii) Draw the straight line of best fit. [1]

(iii) Determine the gradient and y-intercept of this line.

gradient = ...

y-intercept = ...

[2]

(d) It is suggested that the quantities P and M are related by the equation

$$\frac{1}{P} = \frac{a}{\sqrt{M}} + b$$

where a and b are constants.

Use your answers in **(c)(iii)** to determine the values of a and b.
Give appropriate units.

a = ...

b = ...
[2]

[Total: 20]

You may not need to use all of the materials provided.

4 **(a)** State the value of absolute zero on:

(i) the Celsius temperature scale

temperature = ... °C [1]

(ii) the thermodynamic temperature scale. Give a unit with your answer.

temperature = ... unit .... [1]

(b) A sample contains a fixed amount of gas. The gas has pressure p, volume V and thermodynamic temperature T.

Fig. 4.1 shows the variation of pV with kT for the sample, where k is the Boltzmann constant.

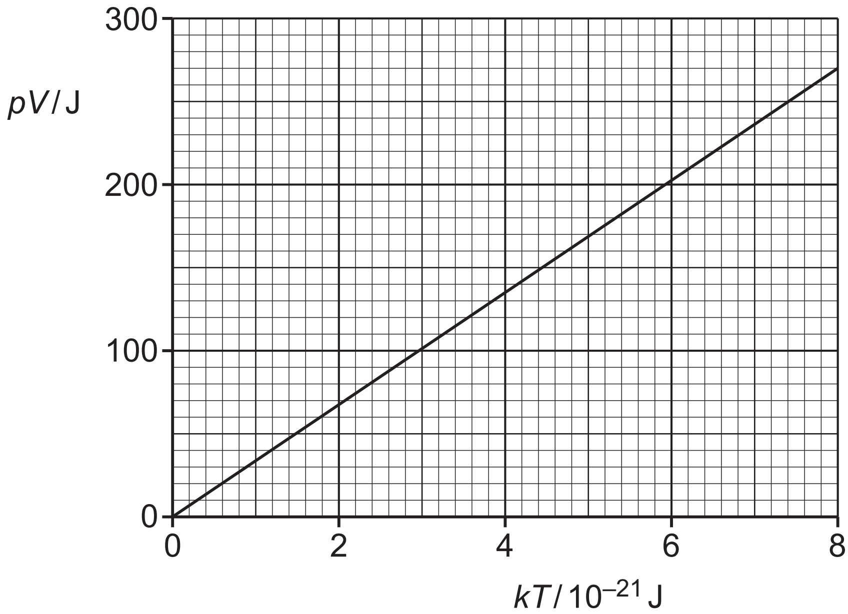

Fig. 4.1

(i) State what is indicated about the nature of the gas from the variation shown in Fig. 4.1.

.... [1]

(ii) Determine the number N of molecules of the gas in the sample.

N = ... [2]

(iii) Use your answer in **(b)(ii)** to determine the amount *n* of gas in the sample.

n = ... mol [1]

(c) The root-mean-square (r.m.s.) speed of the molecules of the gas is 1900 m s^{-1} when *pV* is equal to 270 J.

Determine the mass, in u, of one molecule of the gas, where u is the unified atomic mass unit.

mass = ... u [4]

[Total: 10]

5 **(a)** Define electric potential at a point.

....

....

.... [2]

(b) A hydrogen atom may be considered to consist of a proton and an electron separated by a distance of 120 pm, as shown in Fig. 5.1.

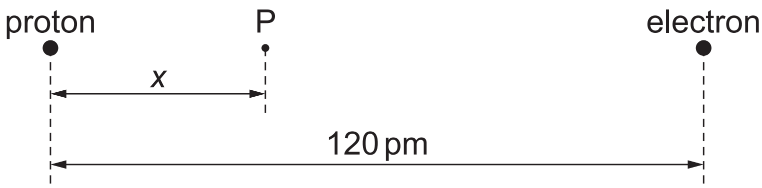

Fig. 5.1

The two particles may be considered as point charges.

Point P lies on the line joining the electron and the proton and is at a variable distance x from the proton.

(i) Show that the electric potential V at point P when x = 10 pm is equal to 130 V.

[2]

(ii) Calculate, to two significant figures, V when x = 30 pm.

V = ...V [2]

(iii) On Fig. 5.1, draw a cross (×) at one position, other than infinity, where the electric potential is zero. [1]

(iv) On Fig. 5.2, sketch the variation of V with x between x = 10 pm and x = 110 pm.

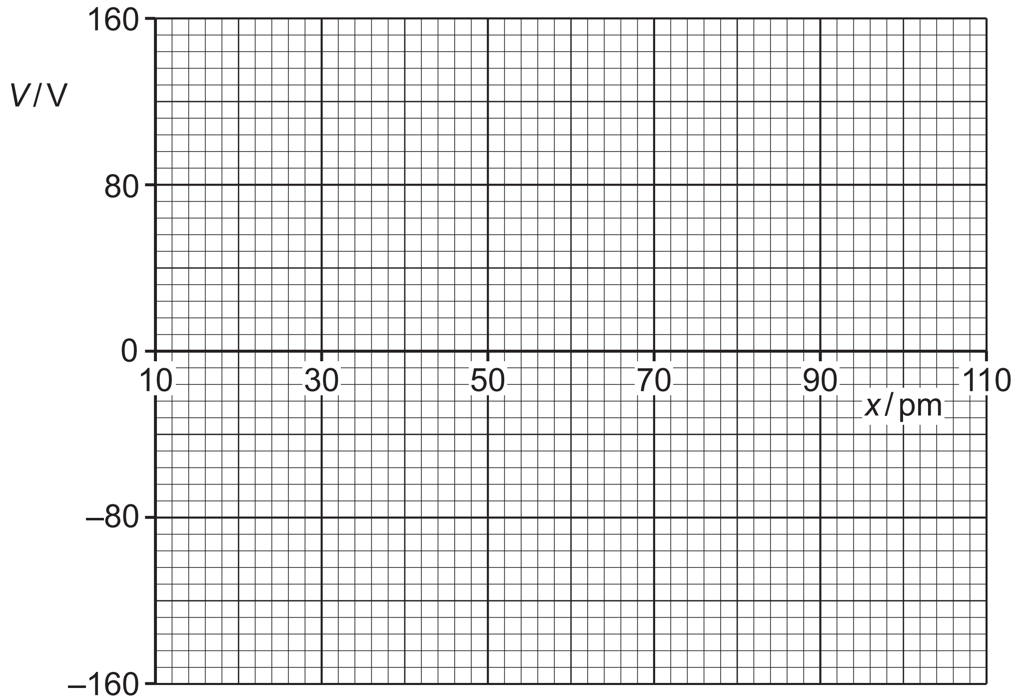

Fig. 5.2

[3]

[Total: 10]

6 **(a)** Two parallel plate capacitors C_1 and C_2 are connected to a supply that has a potential difference (p.d.) V_S. The capacitors may be connected in series or in parallel.

The supply provides charge Q_S and the plates of the two capacitors acquire charges Q_1 and Q_2 respectively. The p.d.s across the plates of the capacitors are V_1 and V_2 respectively.

Complete Table 6.1 to indicate how Q_S, Q_1 and Q_2 relate to each other, and how V_S, V_1 and V_2 relate to each other, for series and parallel connections of the capacitors to the supply.

Table 6.1

	relationship between charges	relationship between p.d.s
series		
parallel		

[4]

(b) An isolated capacitor of capacitance 470 μF stores 19 mJ of energy.

(i) Calculate the p.d. across the capacitor.

p.d. = ...V [2]

(ii) Calculate the charge on the capacitor.

charge = ... C [2]

(iii) The capacitor is now connected in parallel with a capacitor of capacitance 180 μF that is initially uncharged.

Determine the total energy, in mJ, now stored in the two capacitors.

energy = ... mJ [3]

[Total: 11]

1 Fig. 1.1 shows a thin coil of cross-sectional area A and length l connected to a resistor of resistance S and two terminals.

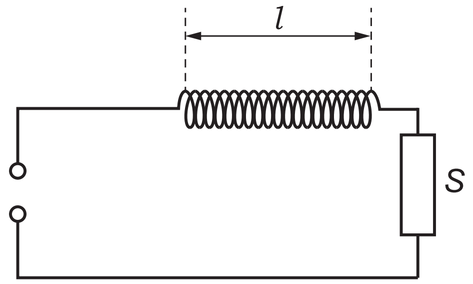

Fig. 1.1

An alternating voltage is applied to the terminals. The peak value of the alternating voltage is E and the frequency is f. The peak value of the potential difference V across the resistor is determined using an oscilloscope.

It is suggested that V is related to f by the relationship

$$\frac{ES}{V} = \frac{KAN^2f}{l}$$

where N is the number of turns on the coil and K is a constant.

Plan a laboratory experiment to test the relationship between V and f.

Draw a diagram showing the arrangement of your equipment.

Explain how the results could be used to determine a value for K.

In your plan you should include:

- the procedure to be followed
- the measurements to be taken
- the control of variables
- the analysis of the data
- any safety precautions to be taken.

Diagram

[15]

3 **(a)** **(i)** State what is meant by an ideal gas.

....

....

.... [2]

(ii) Use one of the basic assumptions of the kinetic theory to explain what can be deduced about the potential energy associated with the random motion of molecules in an ideal gas.

....

....

.... [2]

(b) A sample of 0.26 m^3 of an ideal gas is at pressure 2.0×10^5 Pa and temperature 290 K.

Determine:

(i) the number N of molecules of the gas

N = ... [2]

(ii) the average translational kinetic energy E_K of one molecule of the gas

E_K = ... J [2]

(iii) the internal energy of the gas. Explain your reasoning.

internal energy = ... J [2]

(c) The volume *V* of the gas in **(b)** is now varied, keeping its pressure constant.

On Fig. 3.1, sketch the variation with *V* of the internal energy *U* of the gas.

Fig. 3.1

[2]

[Total: 12]