1 A digital voltmeter with a three-digit display is used to measure the potential difference across a resistor. The manufacturers of the meter state that its accuracy is ±1% and ±1 digit.
The reading on the voltmeter is 2.05 V.

(a) this reading, calculate, to the nearest digit,

(i) a change of 1% in the voltmeter reading,

change = ... V [1]

(ii) the maximum possible value of the potential difference across the resistor.

maximum value = ... V [1]

(b) The reading on the voltmeter has high precision. State and explain why the reading may not be accurate.

....

....

....[2]

2 **(a)** State the two conditions that must be satisfied for a body to be in equilibrium.

1. ....

....

2. ....

.... [2]

(b) Three co-planar forces act on a body that is in equilibrium.

(i) Describe how to draw a vector triangle to represent these forces.

....

....

....

....

....

....

....[3]

(ii) State how the triangle confirms that the forces are in equilibrium.

....

....[1]

(c) A weight of 7.0 N hangs vertically by two strings AB and AC, as shown in Fig. 2.1.

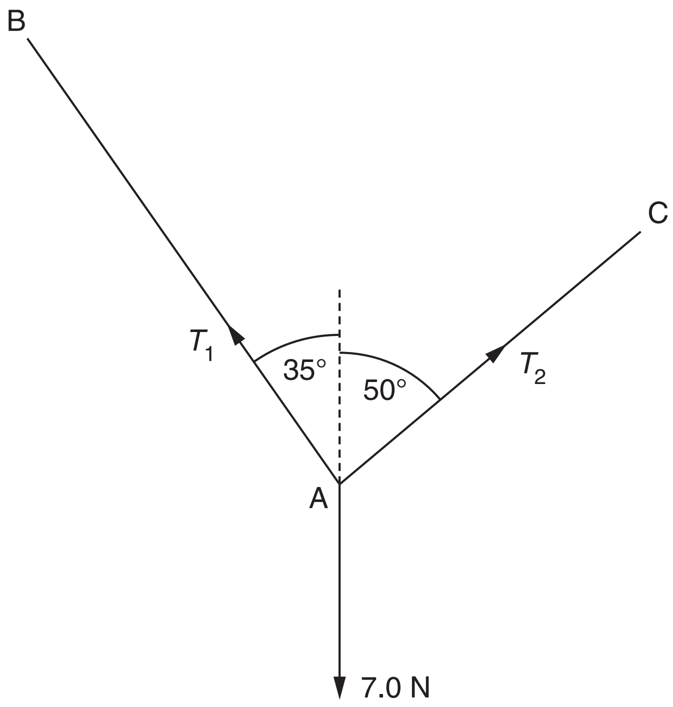

Fig. 2.1

the weight to be in equilibrium, the tension in string AB is T_1 and in string AC it is T_2.

On Fig. 2.1, draw a vector triangle to determine the magnitudes of T_1 and T_2.

T_1 = ... N

T_2 = ... N
[3]

(d) By reference to Fig. 2.1, suggest why the weight could not be supported with the strings AB and AC both horizontal.

....

....[2]

3 A cyclist is moving up a slope that has a constant gradient. The cyclist takes 8.0 s to climb the slope.
The variation with time t of the speed v of the cyclist is shown in Fig. 3.1.

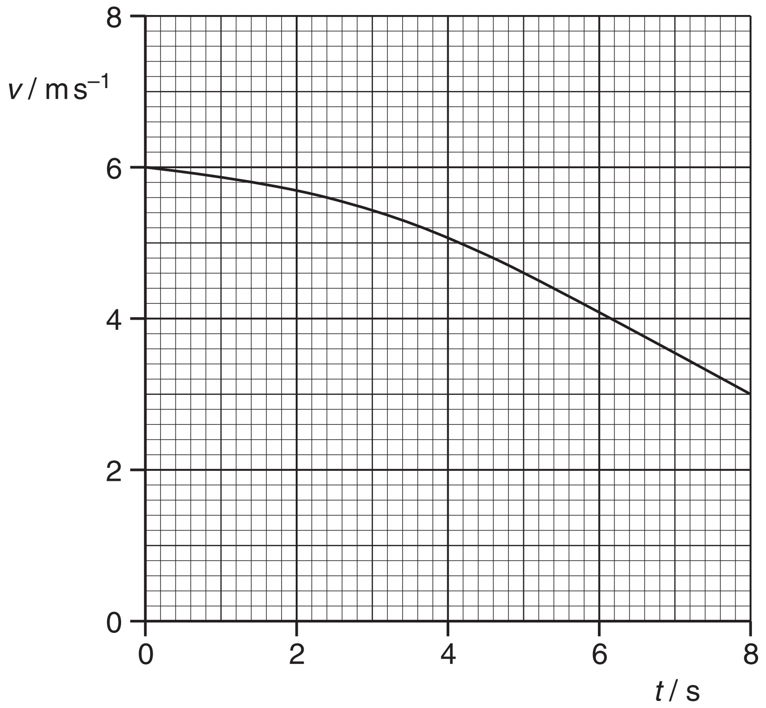

Fig. 3.1

(a) Fig. 3.1 to determine the total distance moved up the slope.

distance = ... m [3]

(b) The bicycle and cyclist have a combined mass of 92 kg.
The vertical height through which the cyclist moves is 1.3 m.

(i) the movement of the bicycle and cyclist between $t = 0$ and $t = 8.0$ s,

1. use Fig. 3.1 to calculate the change in kinetic energy,

change = ... J [2]

2. calculate the change in gravitational potential energy.

change = ... J [2]

(ii) The cyclist pedals continuously so that the useful power delivered to the bicycle is 75 W.
Calculate the useful work done by the cyclist climbing up the slope.

work done = ... J [2]

(c) Some energy is used in overcoming frictional forces.

(i) your answers in **(b)** to show that the total energy converted in overcoming frictional forces is approximately 670 J.

[1]

(ii) Determine the average magnitude of the frictional forces.

average force = ... N [1]

(d) Suggest why the magnitude of the total resistive force would not be constant.

....

....

....[2]

4 **(a)** State the evidence for the assumption that

(i) there are significant forces of attraction between molecules in the solid state,

....

....[1]

(ii) the forces of attraction between molecules in a gas are negligible.

....

....[1]

(b) Explain, on the basis of the kinetic model of gases, the pressure exerted by a gas.

....

....

....

....

....[4]

(c) Liquid nitrogen has a density of $810\,\text{kg}\,\text{m}^{-3}$. The density of nitrogen gas at room temperature and pressure is approximately $1.2\,\text{kg}\,\text{m}^{-3}$.
Suggest how these densities relate to the spacing of nitrogen molecules in the liquid and in the gaseous states.

....

....

....[2]

5 **(a)** A source of sound has frequency f. Sound of wavelength λ is produced by the source.

(i) State

1. what is meant by the *frequency* of the source,

....

....[1]

2. the distance moved, in terms of λ, by a wavefront during n oscillations of the source.

distance = ...[1]

(ii) your answers in **(i)** to deduce an expression for the speed v of the wave in terms of f and λ.

[2]

(b) The waveform of a sound wave produced on the screen of a cathode-ray oscilloscope (c.r.o.) is shown in Fig. 5.1.

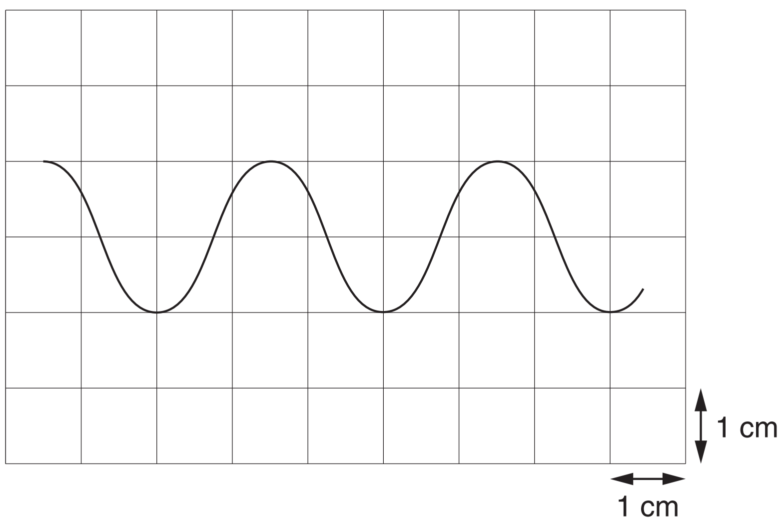

Fig. 5.1

The time-base setting of the c.r.o. is 2.0 ms cm^{-1}.

(i) Determine the frequency of the sound wave.

frequency = ...Hz [2]

(ii) A second sound wave has the same frequency as that calculated in **(i)**. The amplitude of the two waves is the same but the phase difference between them is 90°.

On Fig. 5.1, draw the waveform of this second wave. [1]

6 **(a)** **(i)** State what is meant by an *electric current*.

....

....[1]

(ii) Define *electric potential difference*.

....

....[1]

(b) The variation with potential difference V of the current I in a component Y and in a resistor R are shown in Fig. 6.1.

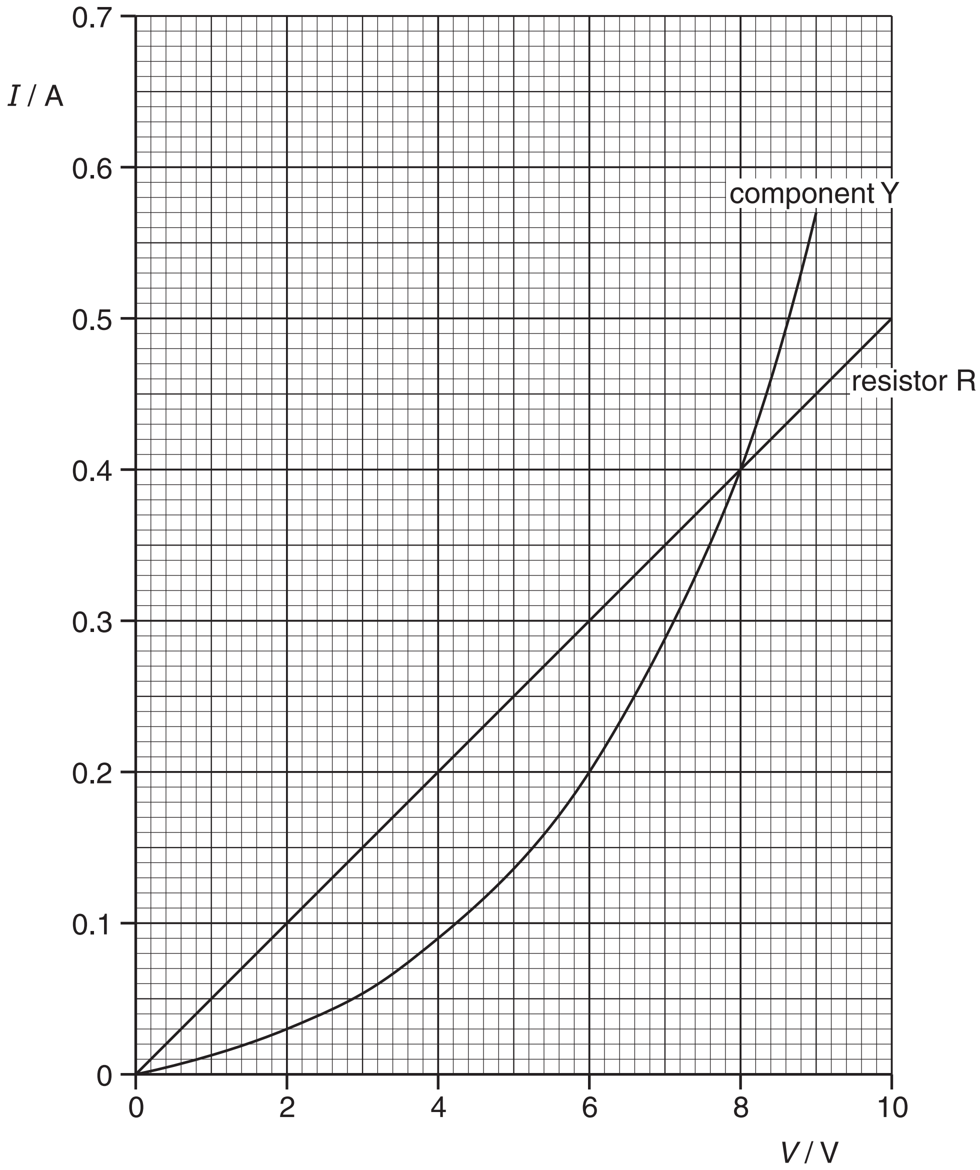

Fig. 6.1

Fig. 6.1 to explain how it can be deduced that resistor R has a constant resistance of 20 Ω.

....

....

....[2]

(c) The component Y and the resistor R in **(b)** are connected in parallel as shown in Fig. 6.2.

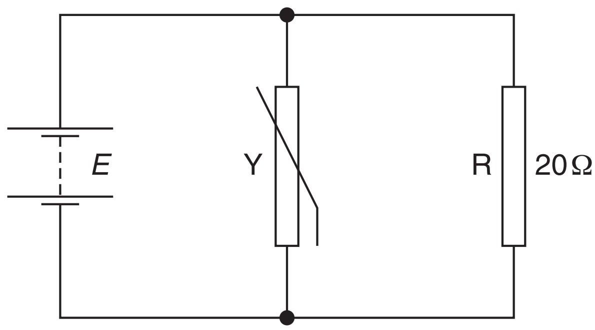

Fig. 6.2

A battery of e.m.f. *E* and negligible internal resistance is connected across the parallel combination.

data from Fig. 6.1 to determine

(i) the current in the battery for an e.m.f. *E* of 6.0 V,

current = ... A [1]

(ii) the total resistance of the circuit for an e.m.f. of 8.0 V.

resistance = ... Ω [2]

(d) The circuit of Fig. 6.2 is now re-arranged as shown in Fig. 6.3.

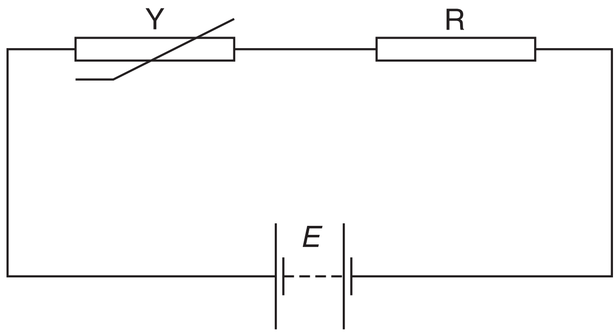

Fig. 6.3

The current in the circuit is 0.20 A.

(i) Fig. 6.1 to determine the e.m.f. E of the battery.

E = ... V [1]

(ii) Calculate the total power dissipated in component Y and resistor R.

power = ... W [2]

7 One property of α-particles is that they produce a high density of ionisation of air at atmospheric pressure. In this ionisation process, a neutral atom becomes an ion pair. The ion pair is a positively-charged particle and an electron.

(a) State

(i) what is meant by an α-particle,

....

....[1]

(ii) an approximate value for the range of α-particles in air at atmospheric pressure.

range = ... cm [1]

(b) The energy required to produce an ion pair in air at atmospheric pressure is 31 eV.
An α-particle has an initial kinetic energy of 8.5×10^{-13} J.

(i) Show that 8.5×10^{-13} J is equivalent to 5.3 MeV.

[1]

(ii) Calculate, to two significant figures, the number of ion pairs produced as the α-particle is stopped in air at atmospheric pressure.

number = ... [2]

(iii) Using your answer in **(a)(ii)**, estimate the average number of ion pairs produced per unit length of the track of the α-particle as it is brought to rest in air.

number per unit length = ... [2]