INTERNATIONAL BACCALAUREATE
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MARKSCHEME

May 2001

PHYSICS

Standard Level

Paper 2

A1. Gas experiment

(a) Because the temperature will have changed when pressure was adjusted; ***[1]***
During waiting, heat flows in or out until the temperature regains its original value (room temperature); ***[1]***

[2 max]

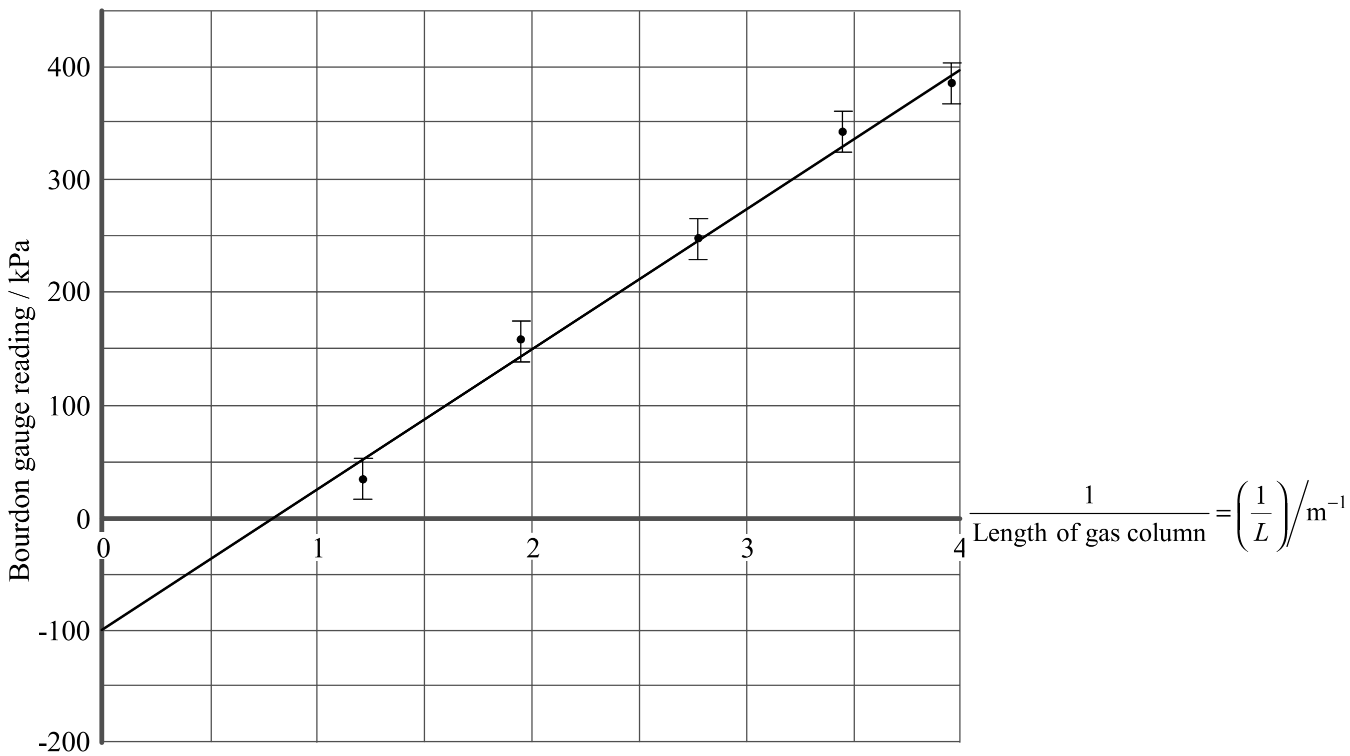
(b) Length of a (uniform) cylinder is proportional to volume; ***[1 max]***

(c) $P = K\left(\frac{1}{V}\right) = K'\left(\frac{1}{L}\right)$; ***[1]***

This is of form $y = mx$ if P is plotted versus $\frac{1}{L}$, ***[1]*** *i.e.* a straight line through origin;

[2 max]

(d) Straight line as below, reasonable best fit by eye with some points on each side of the line; ***[1 max]***



(e) Approximately –100 kPa, corresponding to line drawn; ***[1 max]***

(f) (i) Even an extreme fit, taking error bars into account; ***[1]***
would not pass through origin; ***[1]***
thus random uncertainty is too small to account for deviation from expected straight line through the origin; ***[1]***

[3 max]

(ii) Data gives intercept on pressure axis of –100 kPa, which we note is the value of atmospheric pressure. This may trigger realisation that the Bourdon gauge registers 'gauge' pressure, *i.e.* pressure relative to atmospheric pressure, rather than absolute pressure; ***[1]***

This would account for the offset from the origin, since Boyle's law involves absolute pressure; ***[1]***

[2 max]

(iii) If adjustment of 100 kPa is made, the graph will pass through zero absolute pressure; ***[1]***
and hence data are consistent with Boyle's law; ***[1]***

[2 max]

(iv) Student 3's interpretation is best, and the gas obeys Boyle's law; ***[1 max]***

A2. Arriving at the ground floor

(a)

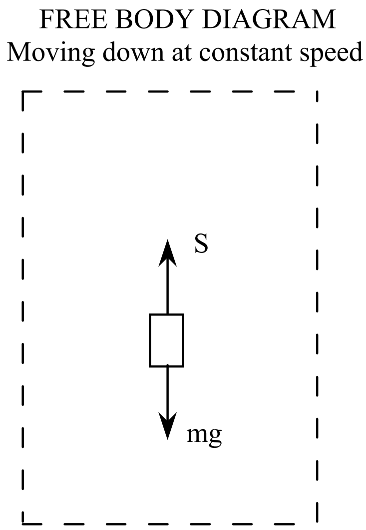


Figure 2

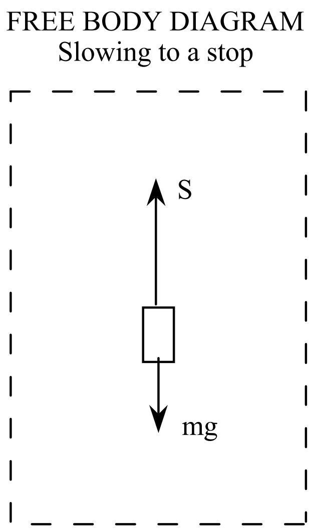


Figure 3

Force S is exerted by the scale, force mg is exerted by the Earth;

Marking: ***[1]*** for **Figure 2** forces equal and opposite, ***[1]*** for **Figure 3** with S>mg, ***[2]*** for naming the two objects exerting the forces;

[4 max]

(b) (i) Constant velocity:

Equilibrium, $S = mg$; ***[1]***

$= 60 \times 10 = 600$ N; ***[1]***

[2 max]

(ii) Slowing:

$S - mg = m\,a$; ***[1]***

$a = \dfrac{\Delta v}{\Delta t}$; ***[1]***

$= \dfrac{3}{2} = 1.5 \text{ m s}^{-2}$; ***[1]***

Thus $S = 60 \times 10 + 60 \times 1.5 = 600 + 90 = 690$ N ; ***[1]***

[4 max]

B1.1 Charge-measuring device

(a) Field lines uniform and from + to – as shown. Do not require edge effect; ***[1 max]***

(b) Positive; ***[1 max]***

(c)

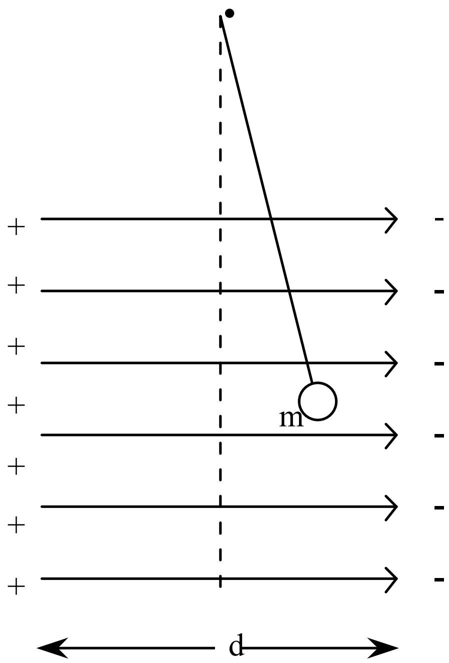


Figure 1: Physical situation

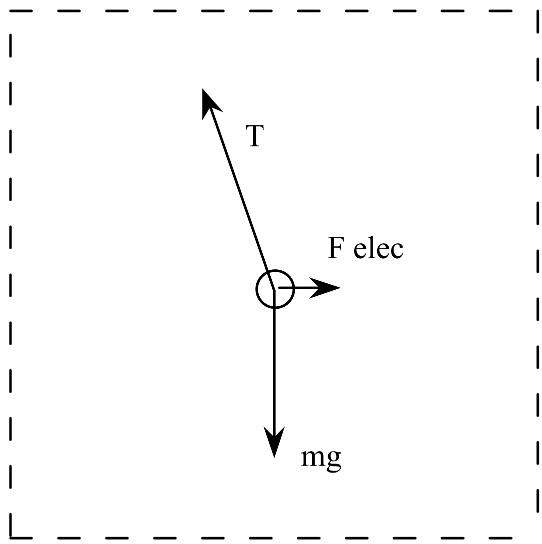


Figure 2: Free-body diagram

Marking: ***[1]*** for each force in the diagram and its label. Penalise two missing labels but not one; ***[3 max]***

However if the candidate has wrong or missing forces, indicating lack of understanding of the equilibrium situation also, give max of ***[1]*** out of ***[3]***.

(d) $W = F.d$ and $F = q\,E$; ***[1]***

so $W = qEd$; ***[1]***

Then $V = \dfrac{W}{q}$ ***[1]*** $= \dfrac{qEd}{q} = Ed$; ***[1]***

Rewriting gives $E = \dfrac{V}{d}$;

[4 max]

(e) Vertical components $T\cos\theta = mg$; ***[1]***

Horizontal components $T\sin\theta = F_{elec} = qE$; ***[1]***

Dividing: $\tan\theta = \frac{Eq}{mg} = \frac{Vq}{dmg}$; ***[1]***

Rewriting: $q = \frac{m\,g\,d\,\tan\theta}{V}$ ***[1]*** $= 40\times10^{-6}\times10\times6\times10^{-2}\times\frac{\tan 20^{\circ}}{480}$; ***[1]***

Therefore = 18 nC ; ***[1]***

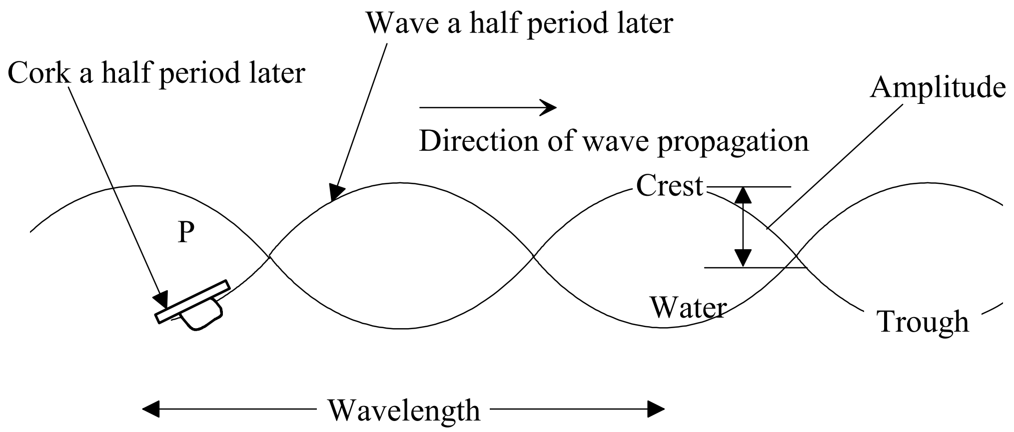
The above is only a guide. Mark by judgement, assessing understanding of equilibrium situation, treatment of force vectors, expressions for forces and algebraic steps. ***[6 max]***

(f) *Any two of the following for* ***[2 max]***

- Smaller mass;
- Higher voltage;
- Smaller separation (not as good since it limits the hanging angle, but accept);
- Longer string — note this is a difficult one: the angle of hanging would be unaffected, but the sideways displacement would be greater; so it depends on what is measured. Accept.

B1 Part 2. Waves in a ripple tank

(a) (i) – (iii) ***[3 max]*** for correct drawing and labelling of each of these;



(b) New wave a half wavelength shifted to the right; ***[1]***
Cork on surface of new wave, shifted vertically but not horizontally; ***[1]***
[2 max]

(c) Cork at A: Moves up and down; ***[1]***

Cork at B: Cork does not move; ***[1]***

Cork at C: Moves up and down; ***[1]***
[3 max]

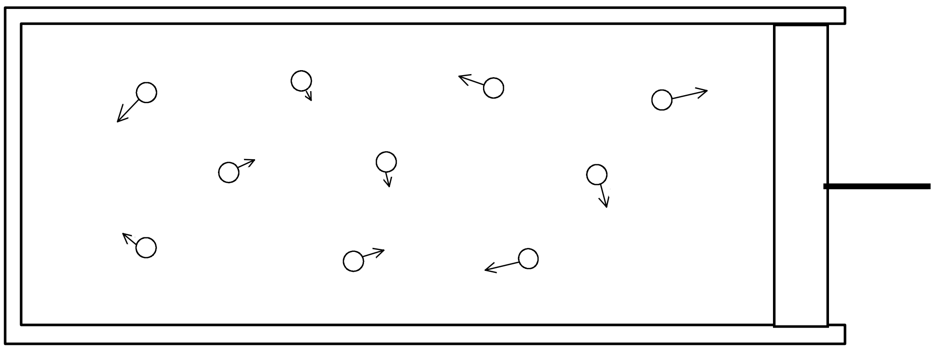
B2.1 Gas expansion

(a) Molecules strike the face and rebound. Explanations of force arising during the collision can be in terms of momentum change, or, acceleration, change of velocity, *etc.*; ***[1]***
Many collisions leads to average force and average pressure; ***[1]***
[2 max]

(b) If they strike the bottom they rebound; ***[1]***
Their average velocities are high compared to any speed they would gain downward due to gravity, between collisions; ***[1]***
(Thus effect of gravity on their motion is negligible);
Look for explanations along the lines of rebounding and comparative effect of gravity.
[2 max]

(c) Average Kinetic Energy of molecules is the same; ***[1]***
since temperature is the same; ***[1]***
[2 max]

(d)



The molecules are more spread out, but have similar representative velocity vectors since the temperature is the same as before; ***[2 max]***

(e) There are fewer collisions of molecules with the piston face per unit time; ***[1]***
because the molecules have further to go before returning or any reasonable expression of the basic ideas, *e.g.* molecules are further apart, so strike the walls less often; ***[1]***
[2 max]

(f) $P_1 V_1 = P_2 V_2$; ***[1]***

$P_2 = \frac{P_1 V_1}{V_2} = 300 \times \frac{1}{2} = 150\text{ kPa}$; ***[1]***

[2 max]

(g) $PV = nRT$, so $\frac{T_2}{T_1} = \frac{P_2}{P_1}$; ***[1]***

$T_2 = \frac{P_2}{P_1} \times T_1 = \frac{300}{150} \times (20 + 273)$; ***[1]***

$= 2 \times 293 = 586\text{ K} = 313\ {}^\circ\text{C}$; ***[1]***

[3 max]

B2. Part 2. Children and bicycle

(a) His feet will stop when they hit the ground but his body will still be travelling forward at the bike speed, so he will fall over forwards or alternative ways of expressing the same ideas; ***[2 max]***

(b) $(m_1 + m_2 + m_3)v = (m_1 + m_2)v' + m_3 \times 0$; ***[2]***

$(10+40+30)\ v = (10+40)\ v'$; ***[1]***

$v' = v \times \frac{80}{50} = 1.6\ v = 1.6 \times 2.5 = 4\ \text{m s}^{-1}$; ***[1]***

Marking: essentially ***[3]*** for knowing what to do, by setting up the right equation and right substitutions, and ***[1]*** for detail and arithmetic.

[4 max]

(c) Before: $\text{KE} = \frac{1}{2}(80)(2.5^2) = 250\ \text{J}$; ***[1]***

After: $\text{KE}' = \frac{1}{2}(50)(4^2) = 400\ \text{J}$; ***[1]***

Increase in KE ***[1]*** is due to energy provided or work done by boy pushing on the bicycle ***[1]***;

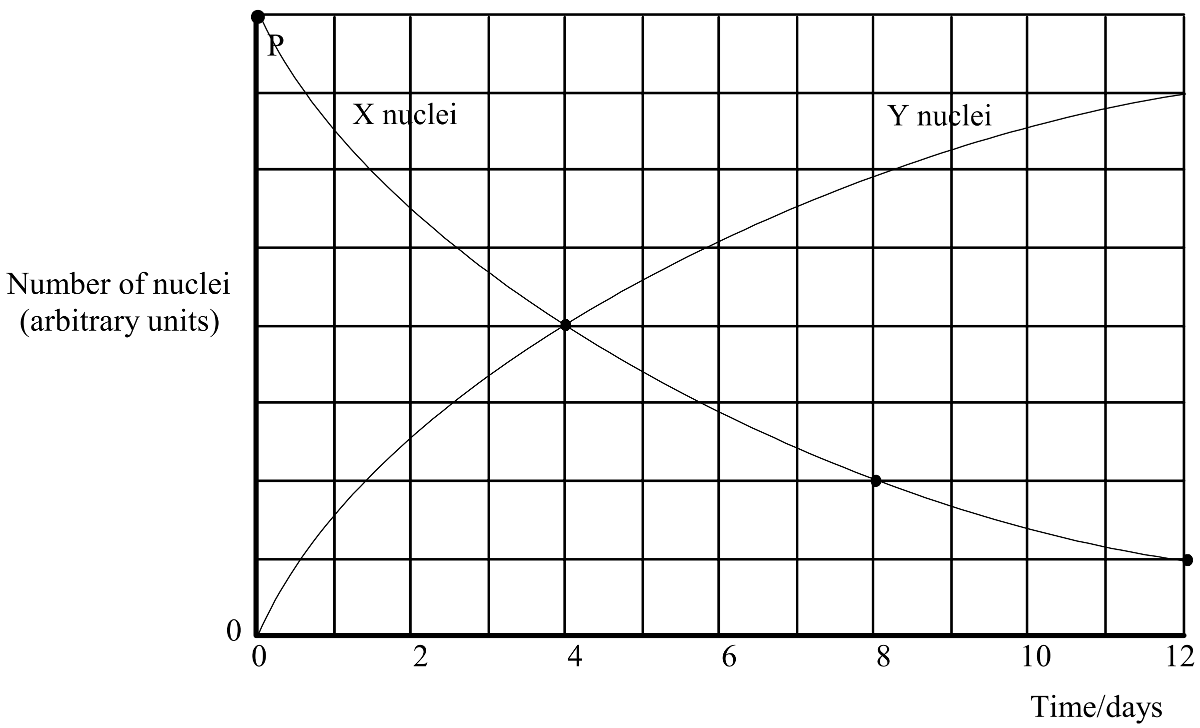
[4 max]

B3.1 Radioactive decay

(a) The nuclei decay (transform spontaneously); ***[1]***
(by emitting alpha, beta or gamma radiation),
such that in each 4.0 days, half of the (remaining undecayed) nuclei decay; ***[1]***
[2 max]

(b) Decay is exponential - process of continuing halving - so requires an 'infinite' time for all the nuclei to day. No definite 'whole-life' to characterise the decay; ***[2 max]***

(c) Graph X below; Look for halving in value in *each* successive 4 days; ***[3]***



(d) Graph Y above. Look for complementary values to graph X, so that X + Y add up to the original number; ***[2 max]***

(e) After 12 days, Y : X = 7 : 1

Accept answers obtained from the graphs or by calculation of proportions of X and Y after 3 half-lives. ***[2 max]***

B3. Part 2. Electric kettle and specific heat capacity of water

(a) Hot water rises by convection; ***[1]***

In a partly filled kettle an element low down would still be immersed; ***[1]***
[2 max]

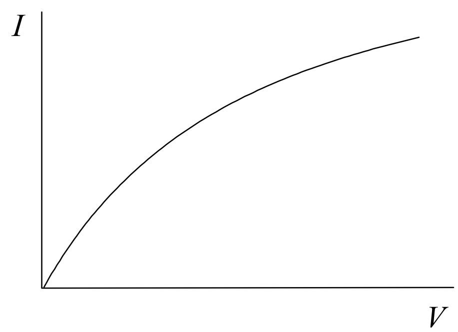
(b) Advantages: *(Any two for **[2]**)*
- Electrically insulating material reduces risk of electric shock;
- Plastic conducts heat less than metal, reduces heat loss;
- Not hot to the touch;

[2 max]

(c) $P = IV$ so $I = \frac{P}{V} = \frac{1100}{220} = 5\text{ A}$; ***[1 max]***

(d) $R = \frac{V}{I} = \frac{220}{5} = 44$ ohms ; ***[1 max]***

(e)



Explanation: Resistance increases as the element gets hotter, hence *I-V* curve has decreasing slope, or else say that current increases less than linearly with V since R increases with temperature. Or similar.

Marking:
Right shape; ***[1]***
Increased temp and resistance; ***[1]***
Relate this to curve; ***[1]***

The assumption above is that element temperature increases. If candidate makes and justifies a different assumption, that temperature is constant due to water immersion, then mark accordingly - graph should then be a straight line.

[3 max]

(f) $ms\,\Delta T = Pt$; ***[1]***

$s = \dfrac{Pt}{m\Delta T}$ with $\Delta T = 100 - 20 = 80$; ***[1]***

$= \dfrac{1100 \times 170}{0.5 \times 80}$; ***[1]***

$= 4675 = 4.7 \times 10^{3}$ J $\text{Kg}^{-1}\ {}^{\circ}\text{C}^{-1}$; ***[1]***

Assumption: no heat losses; ***[1]***

[5 max]