2021 July Common Test H2 Physics Solutions

1 **C** The other three statements are equivalent to the statement "The molecules of the two systems have the same root-mean-square speed". In general, root-mean-square speed is different from mean speed.

2 **C** In equilibrium, the two ideal gases have the same temperature:

$$p_1V_1 = n_1RT,$$
$$p_2V_2 = n_2RT$$

Taking ratio,

$$\frac{p_1V_1}{p_2V_2} = \frac{n_1}{n_2} \Rightarrow \frac{p_1}{p_2} = \frac{n_1V_2}{n_2V_1} = \frac{2.0\times0.50}{3.0\times0.30} = \frac{1.0}{0.90} = 1.1$$

3 **D** A process is adiabatic if there is no heat transfer into or from the gas.

All four processes involve the expansion of an ideal gas. So, work done by the gas is positive, or the work done on the system is negative. If there is not heat absorbed into the system (as in an adiabatic process), the internal energy of the system has to decrease ($\Delta U = W + Q$, with W negative and $Q = 0$, implies that ΔU must be negative). Hence, the temperature of the system has to decrease (since $U \propto T$ for an ideal gas).

4 **A** Option **B**: As a counter example, a system undergoing phase transitions such as melting or boiling has an increasing internal energy at a fixed temperature.

Options **C** and **D**: A system with higher temperature can have less internal energy than another at a lower temperature by having less mass, and vice versa.

5 **D**

$$F = \frac{Qq}{4\pi\varepsilon_0 r^2} = \frac{6\times2}{4\pi\varepsilon_0 d^2} = \frac{12}{4\pi\varepsilon_0 d^2}$$

After contact, both charges have +2.0 μC charge. The electric force is repulsive.

$$F_1 = \frac{2\times2}{4\pi\varepsilon_0\left(\frac{d}{2}\right)^2} = \frac{16}{4\pi\varepsilon_0 d^2} = \frac{4F}{3}$$

6 **B**

$$E = \frac{\Delta V}{\Delta d} = \frac{40}{30\times10^{-3}}$$

$$F_E = qE = \left(5.0\times10^{-6}\right)\left(\frac{40}{30\times10^{-3}}\right)$$

$$\text{work done} = \left(5.0\times10^{-6}\right)\left(\frac{40}{30\times10^{-3}}\right)\left(-12\times10^{-3}\right) = -8.0\times10^{-5}\text{ J}$$

7 **B** electric potential $= \frac{-4Q}{4\pi\varepsilon_0\left(\frac{\sqrt{2}}{2}\right)} + \frac{-3Q}{4\pi\varepsilon_0\left(\frac{\sqrt{2}}{2}\right)} + \frac{2Q}{4\pi\varepsilon_0\left(\frac{\sqrt{2}}{2}\right)} + \frac{Q}{4\pi\varepsilon_0\left(\frac{\sqrt{2}}{2}\right)}$

$$= \left(\frac{-4-3+2+1}{\frac{\sqrt{2}}{2}}\right)\frac{Q}{4\pi\varepsilon_0}$$

$$= -5.09\times10^{10}Q$$

8 **D** $I = nAv_D q$

$$20 = n\times\frac{\pi\times0.0021^2}{4}\times4.5\times10^{-4}\times1.6\times10^{-19}$$

$$n = 8.02\times10^{28}\ \text{m}^{-3}$$

9 **C** There is work done when current flows through internal resistance r and a potential difference across it. Hence, the terminal p.d. decreases.

10 **B** The effect of the increase in the number of charge carriers is large than the effect of an increase in the frequency of collision between lattice ions and charge carriers. Hence, the ratio $\frac{V}{I}$ decreases and the curve gets steeper.

11 **A** Power dissipated, $P = \frac{V^2}{R}$

Since the resistors are identical, $P \propto V^2$

Y and Z are connected in parallel.

Hence,

$V_X : V_Y : V_Z$ or $V_X{}^2 : V_Y{}^2 : V_Z{}^2$

2 : 1 : 1 or 4 : 1 : 1

Power dissipated across X = $\frac{1}{6}\times24 = 4.0$ W

12 **A** Direction of electric force on electrons is upwards.

Therefore, the direction of magnetic force on the electrons has to be downwards (magnetic field is into paper).

Direction of electric force on alpha particles is downwards.

Direction of magnetic force on alpha particles is upwards.

When magnitude of B is increased, the magnetic force ($F_m = B' \times 2e \times v$) is greater than the electric force ($F_E = 2e \times E$).

Hence, the alpha particles deviate towards PQ.

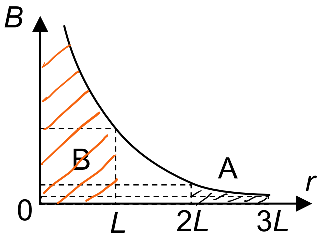
13 **B** $F = BIL\sin\theta$

$F \propto B\sin\theta$

$$\frac{F_2}{F_1} = \frac{B_2\sin\theta_2}{B_1\sin\theta_1} \Rightarrow \frac{F_2}{8} = \frac{\sin60^\circ}{2\sin90^\circ} \Rightarrow F_2 = 3.46\ \text{mN}$$

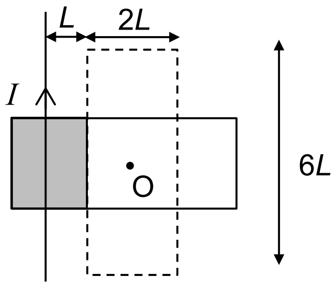
14 C 1. Change in flux linkage = initial flux linkage (final flux linkage is zero)

2. Change in flux linkage = more than initial flux linkage ($B = \dfrac{\mu_0 I}{2\pi r}$)



Area under the graph from L to $3L$ is proportional to the initial flux linkage.
Area under the graph from 0 to $2L$ is proportional is the final flux linkage.
Clearly, change in area (area B – area A) is larger than area under the graph from L to $3L$.

3. Change in flux linkage = less than initial flux linkage (final flux linkage is not zero)



The change in flux linkage in ascending order is 1, 3, 2.

Since the time taken of the changes are the same, the induced emf is in the same order.

15 C Induced emf, $V = \dfrac{\Delta\Phi}{\Delta t}$

Hence, $\Delta t = \dfrac{\Delta\Phi}{V} = \dfrac{NBA - 0}{V} = \dfrac{NBA}{V}$

16 C $\langle P \rangle = \dfrac{V_{\text{rms}}{}^2}{R} \Rightarrow R = \dfrac{V_{\text{rms}}{}^2}{\langle P \rangle} = \dfrac{(120)^2}{500} = 28.8\ \Omega$

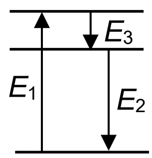
Power dissipated in 240 V d.c. source $= \dfrac{V_{\text{d.c.}}{}^2}{R} = \dfrac{240^2}{28.8} = 2000$ W

17 B $\dfrac{V_s}{V_p} = \dfrac{N_s}{N_p}$

Decreasing number of turns in primary coil will increase the voltage in the secondary coil.

The voltage in the secondary coil is dependent on the ratio of the number of turns between the secondary and primary coils.

18 D Let $E_1 = \dfrac{hc}{\lambda_1}$, $E_2 = \dfrac{hc}{\lambda_2}$ and $E_3 = \dfrac{hc}{\lambda_3}$,



Since $E_1 = E_2 + E_3 \Rightarrow \dfrac{hc}{\lambda_1} = \dfrac{hc}{\lambda_2} + \dfrac{hc}{\lambda_3}$,

$\therefore \dfrac{1}{350} = \dfrac{1}{600} + \dfrac{1}{\lambda_3} \Rightarrow \lambda_3 = 840$ nm (this is infrared radiation)

19 **A**
$$KE = K = \frac{p^2}{2m} = \frac{(h/\lambda)^2}{2m} \quad \Rightarrow \quad K \propto \frac{1}{m\lambda^2}$$
$$\therefore \frac{K_2}{K_1} = \left(\frac{m_1\lambda_1^{\,2}}{m_2\lambda_2^{\,2}}\right) = \left(\frac{m}{4m}\right)\left(\frac{\lambda}{2\lambda}\right)^2 = \frac{1}{16}$$
$$\therefore K_2 = \frac{K}{16}$$

20 **D**
$$\Delta v = \frac{0.50}{100}v = \frac{0.50}{100} \times 15\,000 = 75.0 \text{ m s}^{-1}$$
$$\Delta x \gtrsim \frac{h}{(\Delta p)} = \frac{h}{m\Delta v} = \frac{6.63 \times 10^{-34}}{9.11 \times 10^{-31} \times 75.0} = 9.70 \times 10^{-6} \text{ m}$$

21 **(a)** **(i)** $m = \rho V = 0.905 \times 800 = 724$ kg — B1

(ii) $Q = cm\Delta T = 1050 \times 724 \times (400\text{-}273) = 96545400 = 9.65 \times 10^7$ J — B1

(iii) Since density is inversely proportional to temperature, $\frac{\rho_{273}}{\rho_{400}} = \frac{400}{273}$.

$$\rho_{273} = \frac{400}{273} \times (\rho_{400}) = \frac{400}{273} \times 0.905 = 1.326 = 1.33 \text{ kg m}^{-3}$$ B1

(iv)
$$V_{273} = \frac{m}{\rho_{273}} = \frac{724}{1.326} = 546 \text{ m}^3$$ B1

(b) work done by air $= p\Delta V = p(V_f - V_i) = 1.03 \times 10^5 \times (800 - 546) = 2.62 \times 10^7$ J — B1

(c) $\Delta U = Q + W = 9.65 \times 10^7 + (-2.62 \times 10^7)$ **(M1 for the negative sign)** — M1
$= 7.03 \times 10^7$ J — A1

$\Delta U = \frac{3}{2}P(\Delta V)$ or $\Delta U = \frac{5}{2}P(\Delta V)$ are not acceptable as air is not a monatomic or diatomic gas. It is a mixture of different gases.

(d) 1. Heat is lost through the surface of the balloon to the surrounding air. — B1
2. The balloon itself is heated up. — B1
3. Air spilled out during the heating process carries away some heat (convection).
4. Air outside the balloon was also heated up.

Markers' Comments

(b) Many students made mistakes in the sign of the work done. Instead of relying on the sign in the formula (WD $= -p\Delta V$, which is for work done ON the gas), what you can do is to remember a simple fact: if a gas expands, it does positive work on its surroundings. By this criterion, the work done in this question (BY the gas on the atmosphere) must be positive, so should your final answer for this part be. Also, remember that the work done on a gas and that by the gas differ by a negative sign.

(c) The work done in the first law equation is work done ON the gas, which should be the negative of your answer in **(b)** (which was for work done BY the gas). To score the error-carried-forward mark here if your answer for **(b)** was wrong, you need the above-mentioned negative sign.

(d) Many students stated the two points as “Heat loss to the surroundings” and “Heat loss to the balloon/gas spilt out/atmosphere”. These answers can score only 1 mark out of 2, since the balloon/gas spilt out/atmosphere is part of the surroundings, so the two points are essentially the same point. The question specifically mentioned that we consider only the air of mass *m*. Hence, everything else is part of the “surroundings”. To score both points, students can identify two parts of the environment, which absorb energy via different mechanisms (conduction and convection, for example).

Many students stated that air is not an ideal gas, with intermolecular forces, hence part of heat provided is used to increase the distance between particles, hence more energy is needed for the same amount of temperature change (which only measures the change in the average kinetic energy of the particles). This, although true (hence accepted), is a very small effect. Air under normal conditions is an excellent approximation to an ideal gas. The dominating effect for this question should still be the heat loss to the surroundings via various mechanisms.

22 (a) (i) Length AB = 75.0 – 25.0 = 50.0 cm
p.d. across AB = 3.0 V, hence p.d. across XY = 6.0 V — M1
(because total length of wire is 100 cm, if p.d. across 50 cm is 3 V, then pd across 100 cm is 6 V)

p.d across 2.0 Ω resistor = 12 – 6 = 6.0 V,
hence <u>$\boldsymbol{R_{XY}}$ **= 2.0 Ω**</u> — A1
(since p.d. across 2.0 Ω resistor is the same as p.d. across XY, resistance of XY should therefore be the same as the 2.0 Ω resistor).

(ii)

$$R = \frac{\rho L}{A}$$

$$2.0 = \frac{\rho \times 1.0}{\pi\left(\frac{0.052\times10^{-3}}{2}\right)^2}$$ — M1

$$\rho = 4.25\times10^{-9}\ \Omega\text{m}$$ — A1

(b)

$$E = \frac{R_{AB}}{R_{XY}+2.0}\times12.0 = \frac{0.30\times2.0}{2.0+2.0}\times12.0$$

$$= 1.8\text{ V}$$ — B1

OR $E = V_{AB} = \frac{L_{AB}}{L_{XY}}\times V_{XY} = \frac{30.0}{100}\times6.0 = 1.80\text{ V}$

(c) (i) At balance point, <u>no current passes through resistor *R*</u>, hence no potential drop across *R*. — M1
<u>No change in balanced length</u>. — A1

(ii) The p.d. across XY will be smaller (since there is a potential drop across *r*). — M1
Hence, a <u>longer length *L*</u> will be needed to balance emf *E*. — A1

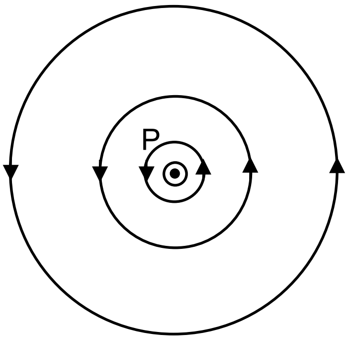
<u>Markers’ Comments</u>

(a) (ii) A significant number of students rounded off 4.247 as 4.24 instead of 4.25.

(c) Some students were not able to identify which circuit (the lower or the upper loop) carries the current when balanced. Most of our tutorial questions have the "driver" cell placed on the upper loop. This is not the case in this question. The "driver" cell is in the lower loop and current will always flow in this loop. A fraction of the p.d. of wire XY is then used to balance cell E, hence cell E has a smaller e.m.f. than the 12.0 V "driver" cell.
Once this is identified correctly, the effect of placing the additional resistor (*R* or *r*) will be apparent.
Students need to know that when the 12 V cell has internal resistance, the e.m.f. has not decreased. It is the terminal p.d. that is now lower than the e.m.f. of the 12 V cell (due to the potential drop across its internal resistance).

23 **(a)** The magnetic flux density of a magnetic field is numerically equal to the force per unit length of a long straight conductor carrying a unit current at right angles to the magnetic field. B1

(b)



B1 for correct circular pattern with at least three circles and increasing distance between circles
B1 for correct direction of field lines

(c) **(i)**

$$B_P = \frac{\mu_0 I}{2\pi r} = \frac{4\pi \times 10^{-7} \times 2.0}{2\pi \times 0.25}$$ M1

$$= 1.60 \times 10^{-6} \text{ T}$$ A1

(ii) $F = BIL$

$$\frac{F}{L} = BI = 1.60 \times 10^{-6} \times 3.0$$ M1

$$= 4.80 \times 10^{-6} \text{ N m}^{-1}$$ A1

(d) Since the current in wire R is larger, the magnetic flux density due to wire R at wire Q is also larger. Hence, the resultant magnetic flux density at wire Q is downwards. M1
Using Fleming's left hand rule, the resultant force experienced by wire Q is towards wire P (to the left). A1
OR
Since the currents in wires P and Q are in opposite directions, they repel each other. Similarly, wires Q and R repel each other. M1
As the current in wire R is larger than the current in wire P, the repulsive force between wires Q and R is larger. Hence, the resultant force experienced by wire Q is toward wire P (to the left). A1

Markers' Comments

(a) A common mistake is to write "unit charge" instead of "unit current". Another common mistake is that the word "unit" is missing from the current.

(d) Many students explained why the force / magnetic flux density acting on Q due to R is larger than that due to P, without any reference to the directions of the force / magnetic flux density. Such answers are not given any credit. A discussion of the magnitude of the forces on Q or magnetic flux densities at Q is necessary only when the forces or magnetic flux densities are in opposite direction.
Students should explain the direction of the forces or net force acting on Q using the key words "Fleming's left hand rule" and not simply state the direction.

24 **(a)** As coil Q moves away from coil P, <u>magnetic flux linkage (magnetic flux density) in coil Q decreases</u> due to the decreasing magnetic field. M1

By Lenz's Law, the induced current in coil Q flows in a direction that <u>opposes the decreasing flux linkage</u> or <u>that produces a magnetic field in the same direction as that of coil P.</u> M1

Hence, the induced current flows in the <u>same direction</u> as that in coil P. A1

(b) **(i)** At $x = 0$, $B = 8.4 \times 10^{-3}$ T
At $x = 0.10$ m, $B = 1.2 \times 10^{-3}$ T B1

Hence, $\Delta B = (1.2 - 8.4) \times 10^{-3}$ T $= -7.2 \times 10^{-3}$ T M1

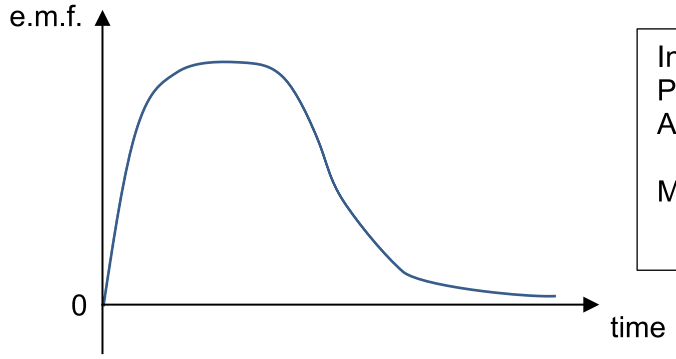
(ii) Induced emf $= \dfrac{d\Phi}{dt}$

$= AN\dfrac{\Delta B}{\Delta t}$ C1

$= 1.5 \times 10^{-4} \times 5000 \times \dfrac{7.2 \times 10^{-3}}{0.25}$

$= 0.0216$ V A1

(c)



Increase – decrease	B1
Plateau	B1
All positive/negative	B1
Maximum deduct **two** marks	

<u>**Markers' Comments**</u>

(a) A significant number of students did not seem to see the arrow in Fig. 24.1 indicating that coil Q is being moved away from coil P. Those who answered based on coil Q approaching coil P are not given any credit. A number of students stated that the direction of the induced current in coil Q is clockwise (or anticlockwise) without referring to the direction of the current in coil P. It is also observed that many students seem to have memorised a standard paragraph and regurgitated it even though most of it (e.g. Faraday's Law) is irrelevant to this question.

(b) **(i)** This is an easy part. A surprisingly large number of students misread $x = 0.100$ m as $x = 0.010$ m.

(b) **(ii)** This is also an easy part. The weaker students mixed up the formula for magnetic flux linkage and induced e.m.f.

(c) The central portion of the graph in Fig. 24.2 has almost constant gradient. Hence, the induced e.m.f. should be nearly constant when coil Q is passing through this region. Most students lost a mark because they showed a rounded maximum point rather than a plateau.

25 **(a)** **(i)** Period, $T = 1.0 \times 2 \times 10 \times 10^{-3} = 0.020$ s — C1

$$f = \frac{1}{T} = 50 \text{ Hz}$$ A1

(ii) $V_0 = 1.0 \times 1 \times 5.0$ — M1

$= 5.0$ V — A1

(iii)

$$V_{rms} = \sqrt{\frac{(3 \times 5.0)^2 \times 10 \times 10^{-3} + (-5.0)^2 \times 10 \times 10^{-3}}{20 \times 10^{-3}}}$$ M1

$= 11.2$ V — A1

(iv)

$$\text{mean power} = \frac{V_{rms}^{\ 2}}{R} = \frac{11.2^2}{1500}$$ M1

$= 0.0836$ W — A1

(b)

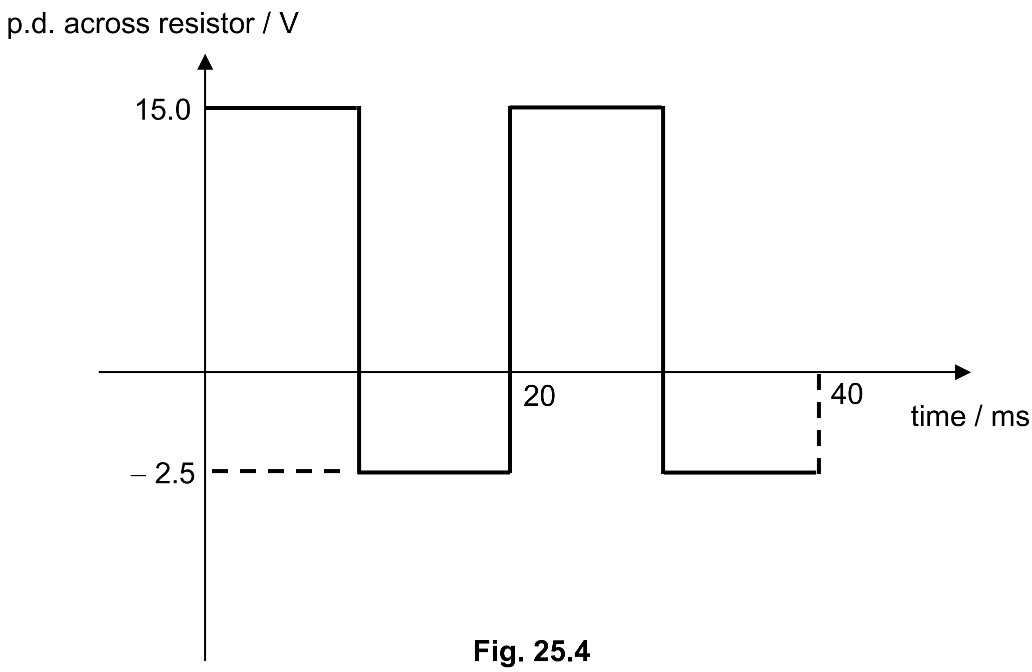


Fig. 25.4

B1 – correct graph and labelling for the positive y-axis
B1 – correct graph and labelling for the negative y-axis
Minus one mark for not labelling the time axis correctly

__**Markers' Comments**__

(a) **(i)** Several students convert 10 ms wrongly to 1 × 10^{-3} s. It should be 10 × 10^{-3} s. Some wrote 10 × 10^{-3} s correctly in their working but typed 1 × 10^{-3} in their calculators to calculate.

(iii) It is important to note that $V_{rms} = \dfrac{V_0}{\sqrt{2}}$ is only valid for **<u>sinusoidal source</u>**. In this question, it is a rectangular a.c. wave and not a sinusoidal source. Hence r.m.s. voltage has to be calculated by squaring the voltages for one period → take average → square root.

(iv) The general formula for mean power of a.c. source is $<P> = V_{rms}^2/R$. Again students should not use $<P> = P_0/2$ as this is only for sinusoidal wave.

(iii) It is important to note that Vrms = $V_{rms} = \dfrac{V_0}{\sqrt{2}}$ is only valid for **<u>sinusoidal source</u>**. In this question, it is a rectangular wave and not a sinusoidal source. Hence r.m.s. voltage has to be calculated by squaring the voltages for one period → take average → square root.

(b) When the diode is forward bias, there is negligible resistance across the diode and hence current will flow through the diode instead of the 1500 Ω resistor that is parallel to it. Hence the p.d. across the 1500 Ω resistor that is parallel to the c.r.o. will be $3V_0$ i.e. 15 V. When the diode is reversed bias, no current passes through diode. Current will flow through the 1500 Ω resistor that is parallel to the diode. Hence the p.d. across the 1500 Ω resistor that is parallel to the c.r.o. will be half of V_0 i.e. 2.5 V. As the current is flowing in opposite direction, the p.d. across the resistor parallel to the c.r.o. will be –2.5 V.

Several students drew the 2.5 V in the negative axis but forgot to add a minus sign to the 2.5 V labelling on the axis.

The question asked to sketch for two cycles. Some student drew more than two cycles. No mark was deducted this time round but please read the question carefully in future.

26 (a) The work function of a metal is the <u>minimum amount of energy</u> necessary for an electron to <u>escape</u> from the surface of the metal. B1

(b) $hf_0 = 6.35 \times 1.60 \times 10^{-19} \Rightarrow f_0 = \dfrac{6.35 \times 1.60 \times 10^{-19}}{6.63 \times 10^{-34}} = 1.53 \times 10^{15}$ Hz B1

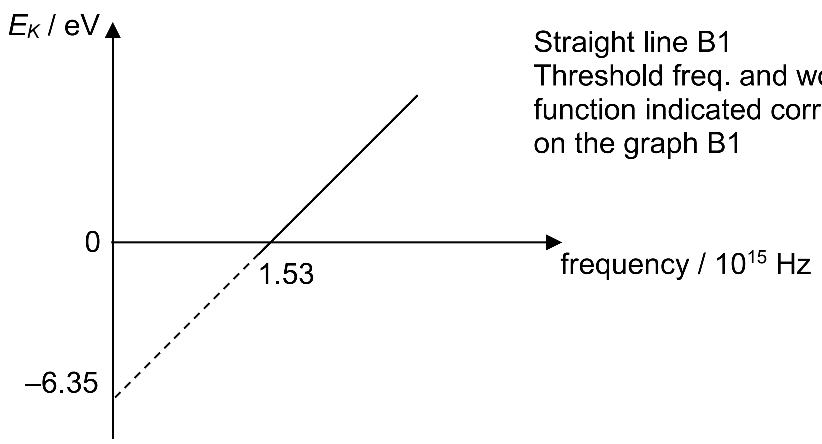
(c)

$$E_{max} = hf - hf_0 = h(f - f_0)$$

$$= 6.63 \times 10^{-34}\left(1.88 \times 10^{15} - 1.5324 \times 10^{15}\right)$$ M1

$$= 2.304 \times 10^{-19} \text{ J} = \frac{2.304 \times 10^{-19}}{1.60 \times 10^{-19}} = 1.44 \text{ eV}$$ A1

(d)



Straight line B1
Threshold freq. and work function indicated correctly on the graph B1

(e) (i) Power $P = \frac{dN}{dt}(hf) \Rightarrow \frac{dN}{dt} = \frac{P}{hf} = \frac{0.25}{6.63\times10^{-34}\times1.88\times10^{15}} = 2.0057\times10^{17}\ \text{s}^{-1}$ B1

Current $I = \frac{dn}{dt}(e) \Rightarrow \frac{dn}{dt} = \frac{I}{e} = \frac{60.0\times10^{-6}}{1.60\times10^{-19}} = 3.75\times10^{14}\ \text{s}^{-1}$ B1

$\therefore$ Percentage of photons that emitted phoelectrons is

$$= \frac{\left(\frac{dn}{dt}\right)}{\left(\frac{dN}{dt}\right)}\times100\ \% = \frac{3.75\times10^{14}\ \text{s}^{-1}}{2.0057\times10^{17}\ \text{s}^{-1}}\times100\ \% = 0.19\ \%$$ A1

(ii) The maximum current will remain the same as before because its value only depends on the rate of photons falling on the metal surface and this is unchanged. B1
(Since the work function is lower than that of platinum, photo-emission will still occur).

Accept also:
Maximum current increases because a larger fraction of the incident photons is capable of ejecting electrons from the metal surface. As a result, there is a higher rate of emission of photoelectrons and hence a higher maximum photoelectric current is obtained (note that this is not in the syllabus).

Markers' Comments
(a) No problem with this part.
(b) Well done for this part.
(c) Well done too for this part.
(d) Mostly well done.
(e) (i) Quite a number of students have forgotten how to do this question (better go back and revise).
(ii) Well done for this part.

27 (a) high momentum / large mass / high speed B1

(b) At higher temperatures, the average kinetic energy of the air molecules (OR root mean square speed of the air molecules OR average speed) is higher. B1

During collisions between air molecules and aerosol particles, aerosol particles will experience greater changes in velocity (speed and direction of motion). B1

There will also be an increase in the frequency of collisions between air molecules and aerosol particles. B1

The aerosol particles will have a more erratic motion. B1

(c) loss in kinetic energy $= \left(\frac{1}{2}\right)\left(2.0\times10^{-15}\right)(1.2)^2 - 0 = 1.44\times10^{-15}\ \text{J}$ M1

average force $= \frac{\text{work done}}{\text{displacement}} = \frac{1.44\times10^{-15}}{8.8\times10^{-8}} = 1.64\times10^{-8}\ \text{N}$ A1

(d) **(i)**

$$F_{\text{on P by A}} = \frac{\left(0.050\times10^{-9}\right)\left(0.030\times10^{-9}\right)}{4\pi\varepsilon_0\left(1.5\times10^{-6}\right)^2}$$ M1

$$= 5.99\ \text{N}$$ A1

(ii)

$$\text{EPE} = \frac{\left(+0.050\times10^{-9}\right)\left(-0.030\times10^{-9}\right)}{4\pi\varepsilon_0\left(1.5\times10^{-6}\right)}$$ M1

$$= -8.99\times10^{-6}\ \text{J}$$ A1

(iii)

$$\text{EPE}_\text{i} = -8.9918\times10^{-6}$$

$$\text{EPE}_\text{f} = \frac{\left(+0.050\times10^{-9}\right)\left(-0.030\times10^{-9}\right)}{4\pi\varepsilon_0\left(\left(0.5+0.15\right)\times10^{-6}\right)} = -2.0750\times10^{-5}$$ M1

decrease in EPE = increase in KE

$$\text{EPE}_\text{i} - \text{EPE}_f = \text{KE}_\text{f} - \text{KE}_\text{i}$$

$$-8.9918\times10^{-6} - \left(-2.0750\times10^{-5}\right) = \text{KE}_\text{f} - 4.0\times10^{-6}$$ M1

$$\text{KE}_\text{f} = 1.58\times10^{-5}\ \text{J}$$ A1

(e) **(i)** Possible answers:
As an insulator to prevent short circuit.
OR
To provide significant resistance for the circuit so that current is small. B1

(ii)

$$\text{electric field strength} = \frac{\Delta V}{d}$$

$$= \frac{2000}{0.50\times10^{-2}}$$ M1

$$= 4.00\times10^{5}\ \text{V m}^{-1}$$ A1

(iii)

$P = IV$

$$\text{power required} = 20\times10^{-6}\times2000 = 0.040\ \text{W}$$ B1

(iv)

$$\text{time taken} = \frac{\text{energy capacity}}{\text{power}} = \frac{15000}{0.040} = 375000\ \text{s} = 104\ \text{h}$$ B1

(v) Possible answers:
The strong electric field recharges the polypropylene fibres. B1
The power source replenishes/maintains the charge on the polypropylene fibres.

<u>Markers' Comments</u>

(a) This part was well done.

(b) Many students were able to identify that increase in temperature led to an increase in average speed of molecules and hence a more erratic motion.

Few students scored full credit for this part, as many failed to mention that the aerosol particles experience greater changes in velocity due to the higher average speeds of air molecules.

(c) Many students used the incorrect equation $\Delta p = F \times s$ or assumed constant speed and thus found the time taken using $t = \dfrac{\text{distance}}{\text{speed}}$.

(d) **(i)** Many students mixed up the formula for force and field strength, and at times even potential energy.

(ii) Students either confused the formula for
- potential energy and potential, OR
- mixed up electrical potential energy with gravitational potential energy, and ended up adding an additional negative sign to the EPE formula.

Many students forgot to include the negative sign for the –0.030 nC charge in the calculation for potential energy.

Quite a significant number of students also wrote that EPE is equal to the electric force multiplied by the separation between the two charges. This is wrong as F x d refers to the work done, and work done in this case is from infinity to the point that is a certain distance from the charge that is exerting this force.

It also makes no sense to apply a modulus to the EPE calculation.

(iii) The conservation of energy was very badly.
Students could not tell whether EPE was lost or gained and likewise for KE.
In the end, many implied from the way the values were substituted that the **gain** in EPE was equal to the **gain** in KE.
Some ended up with the correct numerical answers because of the mistakes made in **(ii)** but no answer mark was awarded as the physics applied was wrong.

Many students also assumed that the final EPE was zero and simply equated the gain in KE to the initial EPE calculated in **(ii)**.

Another common mistake was to calculate the change in KE and simply equate it to the final KE.

(e) **(i)** Many suggested that the rubber was there as a heat insulator or to waterproof the mask.
Stating that the rubber electrically insulated the user from electrical shock is incorrect as the rubber is in between the metal frames and the metal frames will still be in contact with the user.

(ii), (iii), (iv) The mistakes here were mainly careless calculation mistakes

(v) Answers given were very vague and unclear.