2025 Physics Prelim P3 Solutions

1 **(a)** **(i)** $v_y{}^2 = u_y{}^2 + 2as_y$ M1

$= 0 + 2(9.81)(32)$

A1

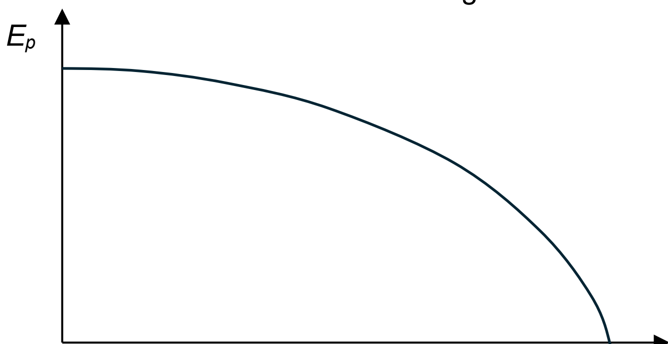
$v_y = 25.1 \text{ m s}^{-1}$

(ii) $\sin\theta = \dfrac{25.1}{34}$ M1

$\theta = 47.6^\circ$ A1

(b) With splashing, there is a transfer of KE of stone to KE of water.
Less KE of stone available to do work against resistive forces in the water. B1

(c) **(i)**

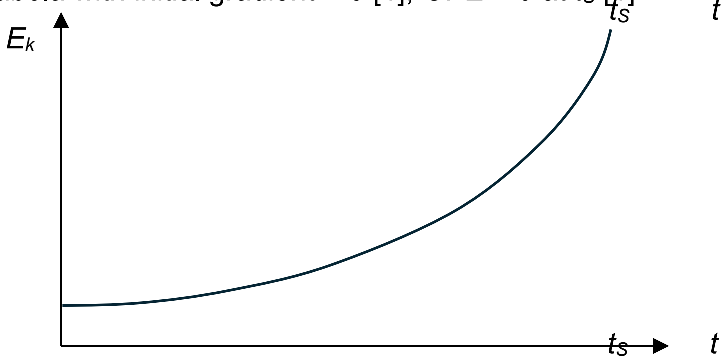


B1

B1

Parabola with initial gradient = 0 [1], GPE = 0 at t_S [1]

(ii)



B1

2 **(a)** Net force on body proportional to rate of change of momentum of the body
(allow eqn with symbols if defined?)

(b) **(i)** $\Delta p = 140 \times 10^{-3} \times [(5.5 - (-4.0)] = 1.33 \text{ kg m s}^{-1}$

(ii) $F_{net} = 1.33 / 0.04$
$= 33.3$ N

Average force on ball due to bar
$= F_{net} + W_{ball}$
$= (1.33 / 0.04) + (9.81 \times 140 \times 10^{-3})$
= 34.6 N

By N3 Fbar =Fball.
=34.6 N = 35 N

(iii) Taking moments about B
$(35 \times 0.75) + (0.450 \times 9.81 \times 0.25) = F_A \times 0.20$
$F_A = 137$ N

(iv) loss = ½ (0.140) [$5.5^2 - 4.0^2$] = 0.998 J

(c)

Since initial and final velocities remain the same, the change in momentum of the ball on hitting the bar is unchanged.
However the duration of contact increases, average contact force on bar at point D decreases, leading to lower average contact force at D
And hence a lower exerted force at A

3 **(a)(i)** An ideal gas is one that obeys the ideal gas equation, pV = nRT at all pressures, volumes and temperatures. B1

(ii) $pV = nRT$
$(1.00 \times 10^5)(750 \times 10^{-6}) = n(8.31)(300)$ M1
$n = 0.030$ A1

(b)

	work done on gas / J	heat supplied to gas / J	increase in internal energy of gas / J
Ao B	+360	0	+360
B to C	0	+670	+670
C to D	-810	0	-810
D to A	0	-220	-220

Minus 1 per mistake.

(c) the gas molecules bounce off the receding piston at lower speeds
And hence lower kinetic energy. B1
For an ideal gas, the temperature is proportional to the average kinetic energy of the molecules. B1

(d) The net work by the engine is positive and can be used to move the car (turn the wheels) B1

4 **(a)** $\frac{R}{0.75+R+5.5}\times 4.0=1.3$ C1

$R=3.0\ \Omega$

p.d. across AB $=\frac{5.5}{0.75+3.0+5.5}\times 4.0$ C1

$=2.4$ V A0

(b)(i) $E=\frac{1.50-0.56}{1.50}\times 2.4$ C1

$=1.5$ V A1

(b)(ii) As C is shifted closer to A, the potential at C increases, thus increasing the potential difference between BC. M1

Since the potential between BC will become larger than the terminal p.d. of cell Q, current will now flow from C to B through cell Q. A1

(c)(i) $\frac{R}{L}=5.5/150=0.0367\ \Omega\ \text{cm}^{-1}$ C1

$R=2\times 15\times 0.0367+\frac{1}{5}\left(\frac{150-2\times 15}{5}\times 0.0367\right)$ C1

$=1.28\ \Omega$

$=1.3\ \Omega$ A0

(c)(ii) Since $I = n A v q$, number density n, cross-sectional area A and charge q are the same in both sections XY (consider a single wire) and AX, $v \propto I$. C1

the current through a single wire in XY is 1/5 of the current through AX.

OR

Since the same current flows through sections AX and XY (consider XY as a whole), $v \propto 1/A$.

the cross-sectional area of XY is 5 times the cross-sectional area of AX.

drift velocity v is greater in AX than in XY A1

5 **(a)** **(i)** Charged particles moving perpendicular to a magnetic field will experience a resultant magnetic force perpendicular to its motion. B1

Hence no work is done. By Newton's 2nd Law, the acceleration of the particles is in the same direction as the resultant force. The direction of the particles changes but not its speed. By Newton's 1st law, upon exit, the particles will move in a straight line with a speed of 4500 ms^{-1}. B1

(ii) Magnetic force provides centripetal force for particle's circular motion B1

$F=Bqv=\frac{mv^2}{r}$

$r = \frac{mv}{Bq}$ C1

$= \frac{(2.66 \times 10^{-26})(4500)}{(2 \times 10^{-3})(1.6 \times 10^{-19})}$ A1

= 0.374 m

(b) $r = \frac{mv}{Bq} = \frac{P}{Bq}$ M1

$P = rBq = (0.2)(2 \times 10^{-3})(1.6 \times 10^{-19})$

= 6.4 x10^{-23} kg m s^{-1} A1

6 (a) (i) 10 A1

(ii) $\Delta E = E_4 - E_1 = \frac{hc}{\lambda}$

$= \frac{(6.63 \times 10^{-34} \times 3.00 \times 10^{8})}{97.5 \times 10^{-9}}$ B1

$= 2.04 \times 10^{-18}$ J

$= \frac{2.04 \times 10^{-18}}{1.60 \times 10^{-19}}$

$= 12.75$ eV

$E_4 = E_1 + \Delta E = -0.85$ eV A1

(b) (i) 13.6 eV = work function + eV_s M1

work function = $13.6 - 8.13$

= 5.47 eV A1

(ii) max kinetic energy of photoelectrons = 8.13 eV B1

$8.13 \times 1.60 \times 10^{-19} = \frac{p^2}{2 \times 9.11 \times 10^{-31}}$

$p = 1.5395 \times 10^{-24} = 1.54 \times 10^{-24}$ N s A1

(iii) $p = \frac{h}{\lambda}$

$1.5395 \times 10^{-24} = \frac{6.63 \times 10^{-34}}{\lambda}$ B1

$\lambda = 4.31 \times 10^{-10}$ m A1

(iv) $\Delta p \Delta x \geq h$

$9.11 \times 10^{-31} \times (1.2 \times 10^{6} \times \frac{0.0025}{100}) \times \Delta x \geq 6.63 \times 10^{-34}$ B1

$\Delta x \geq 2.43 \times 10^{-5}$ m

Δx_{min} = 2.2 x 10^{-5} m (1 or 2 sf) A1

(v) Electrons are accelerated to high kinetic energy in a strong electric field. B1
- when a stream of high energy electrons are rapidly brought to rest (decelerated) by collisions with the atoms of tungsten, radiation in the form of X-rays are emitted.
- If the electron loses only part of its initial kinetic energy during the collision with the target atom, the photon emitted has energy equal to the loss in kinetic energy of the bombarding electrons. B1
-Since the loss in kinetic energy can take any value, through the multiple stages of deceleration of electrons in a metal target, a continuous X-ray spectrum is obtained. B1

7 (a) (i) It is a region of space in which a force acts on a body. B1

(ii) It is the electric force per unit **positive** charge acting on a small test charge placed at that point. B1 B1

(iii) To eliminate the possibility of magnetic force due to its motion in a magnetic field. B1

b (i) E is the negative of the potential gradient B1
OR
The electric field strength *E* at a point is numerically equal to the potential gradient at that point and the direction of the *E* field points in the direction of decreasing potential *V*.

(ii) 1.
Potential gradient at P is negative B1
Electric field E = -dV/dx is positive, hence points in the positive x direction B1

2. From Fig. 7.2 dV/dx = 0 at x = 35 cm B1
E = 0 B1
Hence F = eE = 0 B1

3. -Any charges placed on an isolated conducting sphere **resides** entirely **on its outer surface** because of repulsive forces between them. Since there is no charge within the conductor, the **electric field is zero** at every point **inside** the charged conductor. B1

$-E = -\frac{dV}{dr} = 0$ implies that all points inside the conductor are at constant electric potential B1

c (i)

x/cm	V/V	Vx/Vcm
13.0	590	7670
21.0	390	8190

B1 B1

Since Vx not constant, student is incorrect B1

Minimum 2 sets of data needed. x must be read to ½ and V square. Unit of Vx must be given

(ii) The expression would apply only to a single isolated charge.

However, Fig 7.2 shows the resultant potential between spheres A and B (which is the scalar sum of the potentials due to A and B).

d **(i)** By conservation of energy
$1/2mv_{min}^2$-eV = 0 C1

$$v_{min} = \sqrt{\frac{2(1.60 \times 10^{-19})295}{9.11 \times 10^{-31}}}$$

$v_{min} = 1.02 \times 10^7$ m s^{-1} A1

(ii) The electron would approach the spheres along line of minimum electric potential B1
and cross the A-B line at *x* = 35.0 cm B1

8 **(a)** **(i)**

$$0 = 4mV + (A-4)mv$$ B1
$$4V = -(a-4)v$$ B1

(ii)

$$ratio = \frac{4mV^2}{4(A-4)mv^2} \qquad (1)$$ B1

From (i)

$$V = -\left(\frac{A-4}{4}\right)v$$ B1

Sub into (1)

$$ratio = \frac{4(\frac{A-4}{4})^2 v^2}{(A-4)v^2}$$ B1

$$ratio = \frac{A}{4} - 1$$

b **(i)**

$$E_{released} = [m_{Bi} - (m_\alpha + m_{Th})]c^2$$ C1
$$= [211.9459 - (4.0015 + 207.9374)]1.66 \times 10^{-27} \frac{(3.00 \times 10^8)^2}{1.60 \times 10^{-23}}$$ C1 C1
= 654 MeV A1

(ii)

$$\frac{E_\propto}{E_{Th}} = \frac{A}{4} - 1$$
$$\frac{E_\propto}{6.54 - E_\propto} = \frac{212}{4} - 1 = 52$$ C1
$$\frac{6.54}{E_\propto} - 1 = \frac{1}{52}$$
$$E_\propto = 6.42\ MeV$$ A1

c **(i)** Gamma ray is also emitted in the process. Hence energy of alpha particle is smaller B1

(ii) Gamma ray is likely to carry off part of the momentum in a direction different from that of thallium nucleus and alpha particle. By conservation of momentum, the 2 particles cannot move in opposite direction B1 B1 B1

(ii) The expression would apply to an isolated charge. But there are two charged objects here.

d	**(i)**	3600s	A1
	(ii)	Two hours is equivalent to two half lives of bismuth hence number of radioactive bismuth nuclei remaining is approx. N/4, forming 3N/4 thallium nuclei.	B1 B1 B1
		However, thallium has a much smaller half life and would decay quickly to form other nuclei hence number of thallium nuclei is less than 3N/4.	