

H2 JC2 Physics SA 2008

Section A (MCQ)

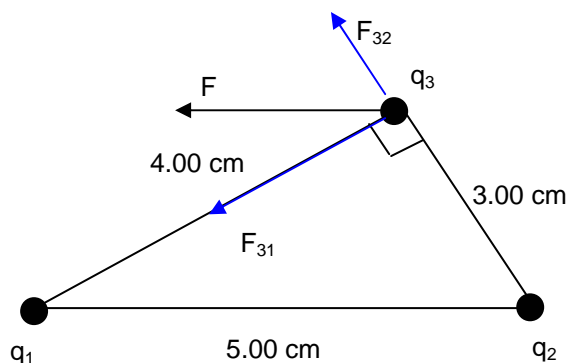
1. D	5. D	9. B	13. D	17. D
2. D	6. A	10. D	14. D	18. B
3. D	7. C	11. D	15. C	19. C
4. B	8. C	12. B	16. D	20. A

Section B (Electricity)

21(a) Electric field strength at a point is defined as the electric force acting per unit positive charge placed at that point.

Electric potential at a point is defined as the work done per unit positive charge by an external agent in bringing a charged body from infinity to that point.

(b)(i)



(b)(ii) At point q_3 :

Vertically:

$$F_{31,y} = F_{32,y}$$

$$\frac{q_1 q_3}{4\pi\epsilon_0 r_1^2} \sin \theta = \frac{q_2 q_3}{4\pi\epsilon_0 r_2^2} \sin \alpha$$

$$\frac{2.00}{4.00^2} \times \frac{3.00}{5.00} = \frac{q_2}{3.00^2} \times \frac{4.00}{5.00}$$

$$q_2 = 0.844 \mu\text{C}$$

or

$$F_{32} = F_{31} \tan \theta$$

$$\frac{q_2 q_3}{4\pi\epsilon_0 r_2^2} = \frac{q_1 q_3}{4\pi\epsilon_0 r_1^2} \tan(\sin^{-1} 3.00 / 5.00)$$

$$q_2 = \left(\frac{2.00}{4.00^2}\right) (3.00)^2 (0.75)$$

$$q_2 = 0.844 \mu\text{C}$$

(b)(iii) $V_3 = V_1 + V_2$

$$= \frac{q_1}{4\pi\epsilon_0 r_1} + \frac{q_2}{4\pi\epsilon_0 r_2}$$

$$= \frac{-2.00\mu}{4\pi\epsilon_0(4.00 \times 10^{-2})} + \frac{0.844\mu}{4\pi\epsilon_0(3.00 \times 10^{-2})}$$

$$= -1.97 \times 10^5 \text{ kV}$$

Misconceptions / Common Errors for Q21

- (a) Many students missed out the phrase “per unit positive charge” for both the definitions.
- (b)(i) Generally, the students are able to indicate the directions correctly. However, they did not pay much attention to the magnitude of the arrows drawn.
- (b)(ii) Many students did not get this right. They simply equate $F_{31} = F_{32}$. Majority cannot even recognise that the vertical component of the resultant force is zero.
- (b)(iii) Very badly done as well. Many students simply find the electric potential due to the point charge q_3 , with some even using the formula for electric potential energy for it.

22(a) The e.m.f. of a source of electrical energy is the energy converted **from other forms into electrical energy per unit charge** supplied by it.

The p.d. across an electrical device is the **electrical energy converted into other forms of energy** per unit charge passing through it.

(b)
$$V_R = \left(\frac{R}{R + r} \right) E$$

(c)(i) There is no current flowing through the circuit at the bottom, so the potential difference across the battery’s internal resistance will always be 0 V. This implies that the potential difference across the battery will always be 2.0 V, hence the position of the sliding contact will not change.

(c)(ii)
$$V_{\text{rod}} = 2.0 \times 2 = 4.0 \text{ V}$$

(c)(iii)
$$\left(\frac{R}{R + r} \right) (4.5) = 4.0$$
$$R = 8.0 \ \Omega$$

Misconceptions / Common Errors for Q22

- (a) Many students gave unacceptable phrases like:
- emf is the force that
 - emf is the work done used to
 - emf occurs between 2 points
 - Emf changes
 - Emf is made up of energies....
- **“per unit charge”** is often missing.
- (b) Generally well done.
- (c) Very badly done and most students have misconception in this question and were unable to relate the effect of internal resistance to the balance length correctly.

Phrases like “the internal resistance is balanced by the resistance of the rod” is frequently seen but this is totally off as we are balancing the pd across the battery and that of the 2 points on the rod.

No mark will be awarded by just stating the answer, explanation **MUST** be given.

(ii), Calculations are not well done, many do not know the potential difference equation or are
(iii) unable to relate the system.

23(a) Circular path to the right or arc

(b) The magnetic force on the electron is *always* perpendicular to the path of the electron, so it changes the direction but not the magnitude of the velocity of the electron.

(c)
$$Bev = \frac{mv^2}{R}$$
$$R = \frac{mv}{Be}$$
$$= \frac{(9.11 \times 10^{-31})(3.6 \times 10^7)}{(2.5 \times 10^{-3})(1.60 \times 10^{-19})}$$
$$= 8.2 \text{ cm or } 0.082 \text{ m}$$

(d) Horizontally to the right

(e) The electric force on the electron to the left balances the magnetic force on it to the right and hence the net force is zero.

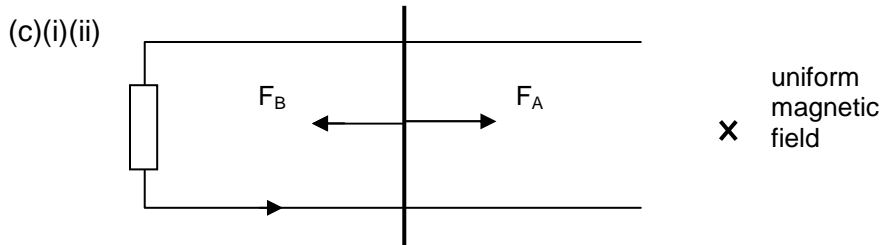
(f)
$$Bev = eE$$
$$E = Bv$$
$$= 2.5 \times 10^{-3} \times 3.6 \times 10^7$$
$$= 9.0 \times 10^4 \text{ V m}^{-1}$$

Misconceptions / Common Errors for Q23

- (a) Different shapes and curves were drawn by candidates to represent the direction of the path electron traveled. Several candidates did not realize that the arrow showed the direction the electron was entering the magnetic field.
- (b) A lot of candidates missed out that the velocity does not change in magnitude but change in direction. Several candidates mentioned that the resultant force is acting perpendicular to the magnetic field or to the right, whereby it should be perpendicular to the path the electron travels.
- (c) It was surprising that some candidates wrote 2.5 mT as 2.5×10^{-6} , 2.5×10^3 or 2.5×10^6 without understanding that $2.5 \text{ mT} = 2.5 \times 10^{-3} \text{ T}$.
- (d) All directions were given, but majority indicated to the right.
- (e) Quite a number of candidates mentioned that the field cancelled each other. Several candidates wrote electric field equal and opposite to magnetic force and vice versa. Some candidates indicated that two forces cancelled each other without mentioning what were the two forces. Candidates should know that electric force is not electrostatic force.
- (f) It was noticed that some candidates solved using $E = Q / 4\pi\epsilon_0 r^2$, which is not correct.

24(a) Arrow to the right

- (b) Lenz's law states that the direction of induced emf is such that if an induced current flows, it will produce an effect to oppose the change causing the induced emf. In this case, the induced current produces a magnetic north on the left of the solenoid which opposes the motion of the magnet. A force has to be applied to move the magnet towards the solenoid, and the work done in moving the magnet is converted to electrical energy when induced current flows in the solenoid.



(c)(iii)

$$\begin{aligned} \text{e.m.f.} &= Blv \\ 0.50 &= (0.60)(0.25)v \\ v &= 3.3 \text{ m s}^{-1} \end{aligned}$$

Misconceptions / Common Errors for Q24

- (a) Some do not know the right hand grip rule for solenoid.
- (b) Not being able to relate to conservation of energy. Some answers are vague and many are conceptually incorrect, such as those who wrote that magnetic energy is converted to electrical energy, or those who argued that when the magnet moves towards the solenoid, it is repelled and when it moves away, the magnet will be attracted towards the solenoid and hence energy is conserved.
- (c) (i) (ii) Many do not know Fleming's Left Hand Rule and do not even know that the forces are horizontal in this case.
- (iii) Many used 30 cm as the length instead of 25 cm.

Section C (Waves)

$$\begin{aligned} 25(a) \quad f &= \frac{1}{T} \\ &= \frac{1}{0.020} \\ &= 50 \text{ Hz} \end{aligned}$$

$$\begin{aligned} (b) \quad \omega &= 2\pi f \\ &= 2\pi(50) \\ &= 310 \text{ rad s}^{-1} \end{aligned}$$

$$\begin{aligned} (c) \quad x &= x_0 \sin \omega t \\ &= 0.0030 \sin 310t \end{aligned}$$

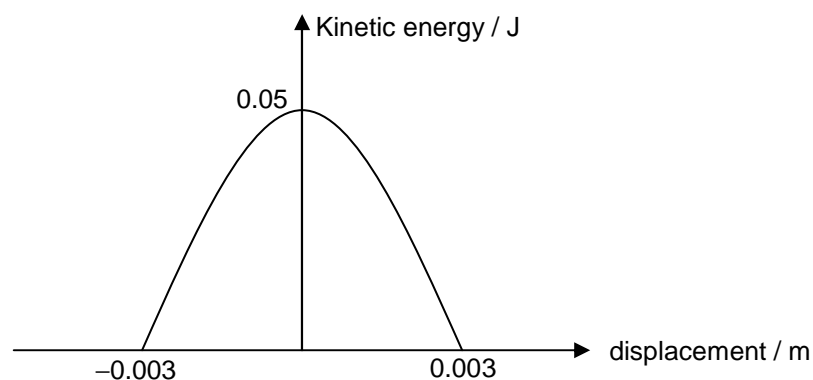
$$(d)(i) \quad 0.90 \text{ m s}^{-1}$$

(d)(ii) Velocity is a vector. The two values correspond to the velocity in the two directions when the particle passes the equilibrium position.

(d)(iii) Zero velocity occurs when the mass attains maximum displacement which occurs on either sides of the equilibrium position.

$$\begin{aligned} (e)(i) \quad KE &= \frac{1}{2} mv^2 \\ &= \frac{1}{2} (0.100)(0.90)^2 \\ &= 0.041 \text{ J} \end{aligned}$$

(e)(ii)



Misconceptions / Common Errors for Q25

(c) Many students leave answer as $x = x_0 \sin \omega t$ without giving a value for x_0 and ω .

(d)(i) Many students gave 1.0 m s^{-1} . ECF marks were awarded for (e)(i).

(d)(ii) Mathematical proofs were not accepted for this question as they do not reflect an understanding of SHM.

(d)(iii) Mathematical proofs were not accepted for this question as they do not reflect an understanding of SHM.

Many students write "maximum & minimum displacement" which is incorrect. What is "minimum displacement"? What do you mean when you talk about a minimum vector? We should instead be writing "maximum displacement in the positive and negative directions".

Also, many students write “maximum amplitude” or “maximum and minimum amplitude”. There is a need for us to be clear about the difference between displacement and amplitude.

(e)(ii) Some students drew a displacement-time graph instead.

26(a) A progressive wave is the movement of a disturbance from a source which transfers energy from the source to points further away.

(b) Longitudinal Waves

○ Particles vibrate along the direction of propagation of the wave.

Transverse Waves

○ Particles vibrate perpendicular to the direction of propagation of the wave.

(c)(i) The amplitude = 0.50 Pa

(c)(ii) $T = (1190 - 350) \times 10^{-6} \text{ s}$
 $= 840 \times 10^{-6} \text{ s}$

$$f = \frac{1}{T}$$
$$= \frac{1}{840 \times 10^{-6}}$$
$$= 1190 \text{ Hz}$$

(c)(iii) $\lambda = \frac{v}{f}$
 $= \frac{340}{1190}$
 $= 0.29 \text{ m}$

Misconceptions / Common Errors for Q26

(a) Many students gave unacceptable phrasing like:

Progressive wave is energy transferred ..

Progressive wave are waves which “move” moving energy from one to another.

(b) Many students gave unacceptable phrasing like:

Longitudinal wave propagated along the direction of the wave motion, transverse wave propagated perpendicular to the direction of the wave motion.

Longitudinal wave are waves which travel parallel to the direction of the wave and transverse waves are waves which travel perpendicularly to the wave.

No clear distinction between the vibration of the particles in the medium and direction of propagation of the wave.

(c) Do not know that $1 \mu\text{s} = 1 \times 10^{-6} \text{ s}$

Use the wrong formula $f = v\lambda$

Read the time axis as the distance axis.

Submit $v = 330 \text{ m s}^{-1}$ instead of the value given of 340 m s^{-1}

$$27(a)(i) \quad \text{Grating spacing} = \frac{1 \times 10^{-3}}{400} \\ = 2.5 \times 10^{-6} \text{ m}$$

$$(a)(ii) \quad d \sin \theta = n\lambda \\ \sin \theta = \frac{\lambda}{d} \\ = 0.24 \\ \theta = 13.9^\circ$$

$$(a)(iii) \quad \sin \theta = \frac{n\lambda}{d} \leq 1 \\ n \leq \frac{d}{\lambda} \\ n \leq 4.2$$

Therefore highest order that can be seen is the 4th order.

$$(b) \quad d \sin \theta = n\lambda \\ (2.5 \times 10^{-6}) \sin (21.4^\circ) = 2\lambda \\ \lambda = 456 \times 10^{-9} \text{ m or } 456 \text{ nm}$$

- (c) The fractional uncertainty in measuring the diffraction angle in a diffraction grating experiment is smaller than that in measuring the fringe separation in a Young's Double Slit experiment.

Misconceptions / Common Errors for Q27

- (a) (i) Well done in general.
Some students were careless with the units (forgot to convert mm to metres).
Some students appeared to have no idea of what grating spacing is.
- (ii) Straightforward question that was well done.
Some students did not know that $1 \text{ nm} = 1 \times 10^{-9} \text{ m}$.
Some students obtained strange answers (e.g. $\theta = 0.00012^\circ$) with correct workings but wrong value of d (due to mistake in (i)).
- (iii) A number of students were penalized for making the wrong conclusion $n = 4.17 \approx 4$.
Some students obtained strange answers with correct workings but incorrect value of d (e.g. $n = 4400$).
- (b) Well done.
- (c) Almost everyone failed to score any marks for this part.
Most students quoted brightness as the reason which is not true.