Neap

Trial Examination 2023

Suggested Solutions

QCE Physics Units 1&2

Paper 2

SECTION 1

QUESTION 1 (5 marks)

a) impulse = $\Delta F \Delta t$ = area under graph

$$\begin{aligned} \text{area} &= \text{rectangle} + \text{triangle} \\ &= (6 \times 8) + (0.5 \times 4 \times 4) \\ &= 56 \text{ N s} \end{aligned}$$

[2 marks]
1 mark for showing understanding that impulse is the area under the graph.
Note: This mark may be implied by subsequent working.
1 mark for calculating the impulse.

b) $\text{impulse} = \Delta p = m\Delta v$

$$56 = 7(\Delta v)$$

$$\Delta v = 8 \text{ m s}^{-1}$$

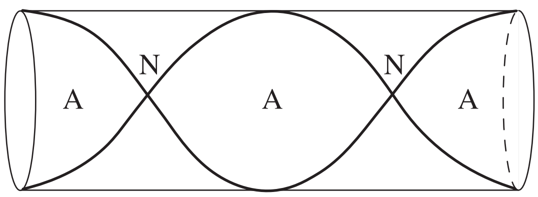
$$\Delta v_{\text{final}} = 8 + 6$$

$$= 14 \text{ m s}^{-1}$$

[3 marks]
1 mark for showing understanding that impulse is the change in momentum.
Note: This mark may be implied by subsequent working.
1 mark calculating the change in velocity.
1 mark for determining the final velocity.
Note: The direction is not required to obtain full marks.
Consequential on answer to ***Question 1a)****.*

QUESTION 2 (5 marks)

a)



[2 marks]
1 mark for sketching a standing wave (two waves out of phase).
1 mark for labelling two nodes and three antinodes.

b) $L = n\frac{\lambda}{2}$

$0.60 = 2\left(\frac{\lambda}{2}\right)$

$\lambda = 0.60 \text{ m}$

$v = f\lambda$

In air at 25°C, the speed of sound is 346 m s^{-1} (per the Formula and Data Booklet). Therefore:

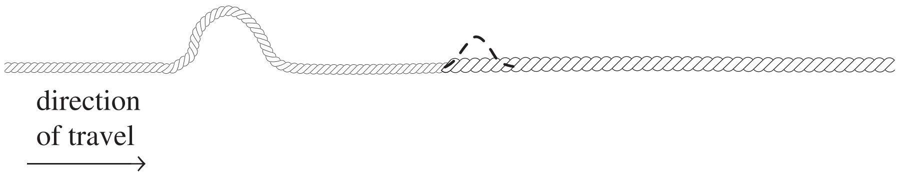
$346 = f \times 0.60$

$f = 577 \text{ Hz}$

[3 marks]
1 mark for substituting into the standing wave formula.
1 mark for calculating the wavelength.
1 mark for calculating the frequency.

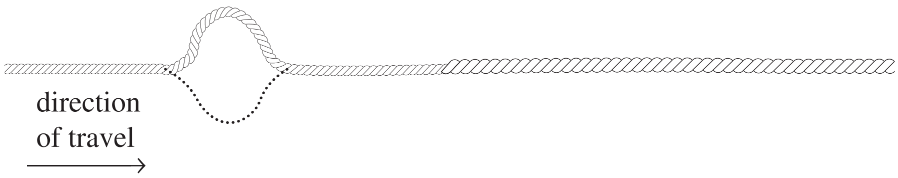
QUESTION 3 (4 marks)

a)



[2 marks]
1 mark for sketching a pulse that shows a reduced magnitude.
1 mark for sketching a pulse that shows a non-inverted orientation.

b)



[2 marks]
1 mark for sketching a pulse that shows a reduced magnitude.
1 mark for sketching a pulse that shows an inverted orientation.

QUESTION 4 (3 marks)

a) $$\text{time} = \frac{\text{distance}}{\text{speed}}$$
$$= \frac{35}{346}$$
$$= 0.10 \text{ s}$$

[1 mark]
1 mark for stating the length of time.

b) $$I \propto \frac{1}{r^2}$$
$$\frac{I}{4} \propto \frac{1}{4r^2}$$
$$\frac{I}{4} \propto \frac{1}{(2r)^2}$$

When the distance is doubled, the intensity decreases by a factor of 4. Therefore, the person would have needed to be twice as far away from the lightning strike than they were.

$2 \times 35 = 70$ m

[2 marks]
1 mark for determining that the distance would need to be doubled.
1 mark for determining the distance.

QUESTION 5 (6 marks)

$$V_{R_5} = I_{R_6 \text{ and } R_7} \times R_{R_6 \text{ and } R_7}$$
$$= 1.00 \times (5.00 + 10.00)$$
$$= 15.0 \text{ V}$$

$$I_{R_5} = \frac{V_{R_5}}{R_{R_5}}$$
$$= \frac{15.0}{20.0}$$
$$= 0.750 \text{ A}$$

$$I_{R_4} = 1.00 + I_{R_5}$$
$$= 1.00 + 0.750$$
$$= 1.75 \text{ A}$$

$$V_{R_4} = I_{R_4} \times R_{R_4}$$
$$= 1.75 \times 2.00$$
$$= 3.50 \text{ V}$$

$$V_{R_3} = V_{R_5} + V_{R_4}$$
$$= 15.0 + 3.50$$
$$= 18.5 \text{ V}$$

$$I_{R_3} = \frac{V_{R_3}}{R_{R_3}}$$
$$= \frac{18.5}{60.0}$$
$$= 0.308 \text{ A}$$

[6 marks]
1 mark for calculating the voltage through R_5.
1 mark for calculating the current through R_5.
1 mark for calculating the current through R_4.
1 mark for calculating the voltage through R_4.
1 mark for calculating the voltage through R_3.
1 mark for calculating the current through R_3.
Note: Accept follow-through errors.

QUESTION 6 (5 marks)

$$-Q_{\text{lost}} = Q_{\text{gained}}$$

$$-(m_{\text{w}} \times c_{\text{w}} \times \Delta T_{\text{warm water}}) = (m_{\text{i}} \times c_{\text{i}} \times \Delta T_{\text{i}}) + (m_{\text{i}} \times L_{\text{f}}) + (m_{\text{i}} \times c_{\text{w}} \times \Delta T_{\text{cold water}})$$

$$-\left(1 \times \left(4.18 \times 10^{3}\right) \times (10.2 - 30)\right) = \left(m_{\text{i}} \times \left(2.05 \times 10^{3}\right) \times (0 - (-18))\right) + \left(m_{\text{i}} \times \left(3.34 \times 10^{5}\right)\right)$$
$$+\left(m_{\text{i}} \times \left(4.18 \times 10^{3}\right) \times (10.2 - 0)\right)$$

$$82\ 764 = m_{\text{i}}\left(36\ 900 + \left(3.34 \times 10^{5}\right) + 42\ 636\right)$$

$$m_{\text{i}} = 0.2001 \text{ kg}$$
$$= 200.1 \text{ g}$$

Since there were 10 ice cubes, one ice cube would have had an initial mass of 20 g.

[5 marks]
1 mark for recognising that ice warms, then melts, and then the new water will warm.
1 mark for using the appropriate heat capacities in the formula.
1 mark for substituting into the formula.
1 mark for determining the total initial mass of 10 ice cubes.
1 mark for determining the initial mass of one ice cube.

QUESTION 7 (4 marks)

a)
$$\frac{\sin i}{\sin r} = \frac{n_2}{n_1}$$
$$\frac{\sin(49)}{\sin r} = \frac{1.50}{1.65}$$
$$r = \sin^{-1}\left(\frac{1.65}{1.50} \times \sin(49)\right)$$
$$= 56.1°$$

[2 marks]
1 mark for substituting into the formula.
1 mark for calculating the angle of refraction.

b)
$$\frac{\sin i}{\sin r} = \frac{n_2}{n_1}$$
$$\frac{\sin i_{\text{critical}}}{\sin(90)} = \frac{1.50}{1.65}$$
$$i_{\text{critical}} = \sin^{-1}\left(\frac{1.50}{1.65}\right)$$
$$= 65.4°$$

[2 marks]
1 mark for substituting into the formula. Note: Responses must show that r = 90° to obtain this mark.
1 mark for calculating the critical angle.

QUESTION 8 (5 marks)

a) *For example:*

$$P = \frac{W}{t}$$

$$2000 = \frac{W}{30}$$

$$W = 60\,000 \text{ J over 30 s}$$

$$m = \frac{Q}{c\Delta T}$$

$$= \frac{60\,000}{\left(4.18\times10^3\right)\times(90-20)}$$

$$= 0.205 \text{ kg}$$

[2 marks]

1 mark for substituting into the formulas using appropriate temperatures and times. Note: Accept any appropriate temperatures and times.

1 mark for determining the mass.

b) $$Q = m_{\text{water}}c\Delta T + m_{\text{water}}L_{\text{v}}$$

$$= \left(0.205\times\left(4.18\times10^3\right)\times(100-20)\right) + \left(0.205\times\left(2.26\times10^6\right)\right)$$

$$= 68\,552 + 463\,300$$

$$= 531\,852 \text{ J}$$

$$t = \frac{W}{P}$$

$$= \frac{531\,852}{2000}$$

$$= 266 \text{ s}$$

[3 marks]

1 mark for substituting into the formula for heat energy.

1 mark for calculating Q. Note: Accept values in the range of 518 000–545 000 J.

1 mark for determining the length of time. Note: Accept values in the range of 259–273 s.

*Note: Accept follow-through errors. Consequential on answer to **Question 8a)**.*

QUESTION 9 (13 marks)

a) i) $${}^{38}_{20}\text{Ca} \rightarrow {}^{38}_{19}\text{K} + {}^{0}_{1}e + \nu_e + \gamma$$

[2 marks]

1 mark for providing the daughter isotope.

1 mark for providing the emitted decay products. Note: γ is not required to obtain full marks.

ii) $${}^{35}_{15}\text{P} \rightarrow {}^{35}_{16}\text{S} + {}^{0}_{-1}e + \bar{\nu}_e + \gamma$$

[2 marks]

1 mark for providing the daughter isotope.

1 mark for providing the emitted decay products. Note: γ is not required to obtain full marks.

iii) $^{241}_{95}\text{Am} \rightarrow {}^{237}_{93}\text{Np} + {}^{4}_{2}\text{He} + \gamma$

[2 marks]

1 mark for providing the daughter isotope.

1 mark for providing the emitted decay products. Note: γ is not required to obtain full marks. Accept $^{4}_{2}\propto$ for the alpha particle.

b) Converting the mass of one atom of $^{12}_{6}\text{C}$ gives:

$$12 \text{ amu} = 12 \times 1.66 \times 10^{-27} \text{ kg}$$
$$= 1.992 \times 10^{-26} \text{ kg}$$

Using the Formula and Data Booklet, the component masses for this isotope are:

$$\text{component masses for } ^{12}_{6}\text{C} = 6 \text{ protons} + 6 \text{ neutrons} + 6 \text{ electrons}$$
$$= (6 \times 1.6726219 \times 10^{-27}) + (6 \times 1.6749275 \times 10^{-27}) + (6 \times 9.1093835 \times 10^{-31})$$
$$= 2.009076203 \times 10^{-26} \text{ kg}$$

$$\Delta m = (2.009076203 \times 10^{-26}) - (1.992 \times 10^{-26})$$
$$= 1.707620301 \times 10^{-28} \text{ kg}$$

$$\Delta E = mc^2$$
$$= 1.707620301 \times 10^{-28} \times c^2$$
$$= 1.707620301 \times 10^{-28} \times (3 \times 10^8)^2$$
$$= 1.536858271 \times 10^{-11} \text{ J}$$

$$\Delta E = \frac{1.536858271 \times 10^{-11}}{1.60 \times 10^{-19}}$$
$$= 9.605364193 \times 10^{7} \text{ eV}$$
$$= 96 \text{ MeV}$$

[5 marks]

1 mark for converting the mass of $^{12}_{6}C$ into kilograms.

1 mark for calculating the component masses for $^{12}_{6}C$.

1 mark for calculating the mass defect.

1 mark for calculating the binding energy in joules.

1 mark for converting the binding energy into megaelectron volts.

c) From the graph, it can be seen that the binding energy per nucleon is much greater for fusion reactions (left of peak) than fission reactions (right of peak). This means that the percentage yield per unit mass of fusion reactions is greater, and this is due to fusion reactants having more energy release events per unit mass.

[2 marks]

1 mark for stating that fusion reactants have smaller masses or fission reactants have greater masses.

1 mark for explaining that fusion reactants have more energy release events per kilogram.