Neap

Trial Examination 2022

Suggested Solutions

QCE Physics Units 1&2

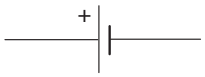
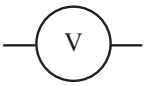
Paper 1

SECTION 1 – MULTIPLE CHOICE QUESTIONS

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

SECTION 1

QUESTION 1 A

Circuit element	Symbol
cell	
light bulb	
resistor	
voltmeter	

QUESTION 2 A

A is correct. The amplitude of a wave is the maximum extent of a vibration or oscillation when measured from the position of equilibrium.

B is incorrect. The frequency of a wave is the number of times a wave completes a full cycle in one second.

C is incorrect. The period of a wave is the time taken for a wave to complete a full cycle.

D is incorrect. The wavelength of a wave is the distance between two corresponding points on the wave.

QUESTION 3 A

A is correct. A vector is a quantity with a magnitude and a direction. Acceleration, force and momentum are all vector quantities.

B, **C** and **D** are incorrect. Each of these lists contains at least one scalar quantity. Time, speed and mass are all scalar quantities.

QUESTION 4 B

B is correct. This option gives the correct definition of latent heat of fusion.

A is incorrect. This option refers to latent heat of vaporisation.

C and **D** are incorrect. These options describe specific heat capacity.

QUESTION 5 A

A is correct. This option shows a velocity–time graph, where the slope of the graph represents acceleration. The constant slope means that the acceleration is constant.

B is incorrect. This option shows a displacement–time graph, where the slope of the graph represents velocity. The constant slope means the velocity is constant.

C is incorrect. This option shows a velocity–time graph, where the slope is not constant and so the acceleration is not constant.

D is incorrect. This option shows a displacement–time graph, where the displacement is not changing and hence is a stationary object.

QUESTION 6 C

C is correct. This option correctly states Newton's second law of motion.

A is incorrect. The statement in this option is correct, but it is not one of Newton's laws.

B is incorrect. This option states Newton's first law of motion.

D is incorrect. This option states an abbreviated form of Newton's third law of motion.

QUESTION 7 D

The intensity (I) of any form of energy (sound, heat or light) radiating outward in three dimensions is inversely proportional to the square of the distance (r) away from the source $\left(I \propto \frac{1}{r^2}\right)$. Therefore, when r triples, I is reduced by a factor of $3^2 = 9$.

QUESTION 8 D

The graphs are a variation of the Boltzmann distribution curve. Objects with the highest temperature will have the greatest proportion of particles with a high average speed. This corresponds to the graph that has a curve that is furthest to the right, which is graph **D**.

QUESTION 9 C

The order of the radiation types when ranked from greatest to least penetrating ability is: gamma, beta, alpha. The order of the radiation types when ranked from greatest to least ionising ability is: alpha, beta, gamma. Therefore, option **C** is correct.

QUESTION 10 B

B is correct. Specific heat capacity is the heat (energy) required to raise the temperature of 1 kg of a substance by 1 degree. Therefore, to raise half a kilogram (500 g) of water by 1 degree, half as much energy (2092 J) is required.

A is incorrect. Increasing the temperature of a lower mass requires less energy, not more.

C and **D** are incorrect. These options refer to the energy required to change from liquid to gas, which is the latent heat of vaporisation, not specific heat capacity.

QUESTION 11 A

A is correct and **D** is incorrect. The half-life of a substance is the amount of time it takes for half of a sample of that substance to undergo nuclear decay.

B is incorrect. The lead-212 does not need to (and, in fact, does not) decay to a stable isotope. It decays to another unstable isotope, which will further decay according to that isotope's half-life.

C is incorrect. Half of the lead-212 will have transmuted into different isotopes; therefore, even though the amount of lead-212 in the sample will have halved, the sample will contain other metals and will still weigh close to 50 g.

QUESTION 12 C

The flat sections of the graph indicate a change of state. The first flat section (from point X to point Y) represents ice changing state to liquid water, and the second flat section (point Z onwards) represents liquid water changing state to steam. Therefore, point X is when the ice starts melting (and changes consistency to part ice and part water), point Y is when the ice has completely melted and point Z is when the liquid water starts boiling.

QUESTION 13 B

B is correct. A conductor that obeys Ohm's Law will have a current flowing through the conductor that is proportional to the voltage drop across the conductor, and $R = \frac{V}{I}$ (the slope) will be constant. This corresponds to a straight, positive line.

A and **C** are incorrect. These options show that the resistance is not constant.

D is incorrect. This option shows that the voltage is not directly proportional to the current.

QUESTION 14 C

C is correct, and **A** and **D** are incorrect. During inelastic collisions, some mechanical energy is lost.

B is incorrect. Momentum is conserved in a isolated system.

QUESTION 15 B

Kinetic energy is given by $E_k = \frac{1}{2}mv^2$. Rearranging the equation in terms of velocity (v) gives $v = \sqrt{\frac{2}{m}} \times \sqrt{E_k}$. Therefore, velocity is proportional to the square root of kinetic energy, $v \propto \sqrt{E_k}$.
Hence, when E_k is increased by a factor of 4, v increases by a factor of $\sqrt{4} = 2$.

QUESTION 16 D

D is correct. The internal energy of an object due to the movement of its particles is called thermal energy.

A is incorrect. Entropy is a measure of the level of disorder in a system.

B is incorrect. Heat is a measure of energy flow from one system to another.

C is incorrect. Temperature is a measure of the average kinetic energy of the particles in a system.

QUESTION 17 A

If the input heat is 500 J and the output heat (waste) is 350 J, 150 J has been used for useful work.
Therefore, the thermal efficiency of the heat engine is $\eta = \frac{150}{500} = 30\%$.

QUESTION 18 C

C is correct. Binding energy is the energy equivalent of the mass defect, as per $\Delta E = \Delta m c^2$.

$$\begin{aligned}\Delta E &= \Delta m c^2 \\ &= 2.63 \times 10^{-27} \times (3 \times 10^8)^2 \\ &= 2.367 \times 10^{10} \text{ J} \\ &= \frac{2.367 \times 10^{10}}{1.60 \times 10^{-19}} \text{ eV} \\ &= 1.48 \times 10^9 \text{ eV}\end{aligned}$$

A is incorrect. This option may be reached if c was not squared.

B is incorrect. This option may be reached if the binding energy was calculated per nucleon.

D is incorrect. This option may be reached if J was not converted to eV.

QUESTION 19 B

The output power is 0.9 W, but the bulb is 10% efficient. So, the input (electrical) power is $\frac{0.9}{0.1} = 9$ W.

$$P = VI$$

$$I = \frac{P}{V}$$

$$= \frac{9}{12}$$

$$= 0.75 \text{ A}$$

QUESTION 20 C

To raise the temperature of 30 g of ice from –100°C to 0°C:

$$Q = mc_i\Delta T$$

$$= 0.03 \times 2.05 \times 10^3 \times 100$$

$$= 6150 \text{ J}$$

To melt 30 g of ice:

$$Q = mL_f$$

$$= 0.03 \times 3.34 \times 10^5$$

$$= 10\ 020 \text{ J}$$

$$\text{total heat energy required} = 6150 + 10\ 020$$

$$= 16\,170 \text{ J}$$

$$= 16.2 \text{ kJ}$$

SECTION 2

QUESTION 21 (2 marks)

68.4 days is 6 half-lives of 11.4 days.

$$N = N_0\left(\frac{1}{2}\right)^n$$
$$= 115 \times (0.5)^6$$
$$= 1.8 \text{ g}$$

[2 marks]
1 mark for determining that 6 half-lives will occur.
1 mark for providing the correct answer.

QUESTION 22 (2 marks)

$^{223}_{88}\text{Ra} \rightarrow {}^{219}_{86}\text{Rn} + {}^{4}_{2}\alpha + \gamma$

OR

$^{223}_{88}\text{Ra} \rightarrow {}^{219}_{86}\text{Rn} + {}^{4}_{2}\text{He} + \gamma$

[2 marks]
1 mark for identifying radon as the daughter nuclide.
1 mark for writing the fully balanced equation.
Note: Accept responses with or without γ to represent energy.

QUESTION 23 (2 marks)

Objects reach thermal equilibrium when the average kinetic energies of the particles in both systems are the same.

When objects reach thermal equilibrium, there is no more net flow of heat between the systems.

[2 marks]
1 mark for providing a statement about the average kinetic energy of particles.
1 mark for providing a statement about the net heat flow.

QUESTION 24 (4 marks)

The initial temperature of the water is 23.0°C.

The final temperature of the water is 31.2°C.

$$\text{heat lost (metal)} = \text{heat gained (water)}$$

$$m_{\text{metal}} c_{\text{metal}} \Delta T_{\text{metal}} = m_{\text{water}} c_{\text{water}} \Delta T_{\text{water}}$$

$$0.233 \times c_{\text{metal}} \times (100 - 31.2) = 0.421 \times 4.18 \times 10^3 \times (31.2 - 23)$$

$$c_{\text{metal}} = 900 \text{ J kg}^{-1} \text{ K}^{-1}$$

[4 marks]
1 mark for reading the initial and final temperatures from the graph (accept ±0.2°C).
1 mark for equating heat gained with heat lost.
1 mark for substituting into the formula.
1 mark for solving for the specific heat capacity of the metal (c).
Note: Accept follow-through errors.

QUESTION 25 (4 marks)

$$\text{gradient} = \frac{\text{rise}}{\text{run}}$$

$$= \frac{0.68}{0.98}$$

$$= 0.69$$

$$\frac{n_1}{n_2} = \frac{\sin(r)}{\sin(i)}$$

$$= \text{gradient}$$

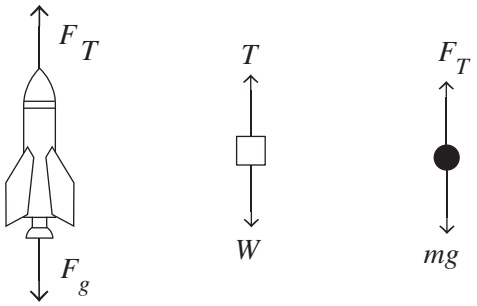
$$\frac{1}{n_2} = \frac{1}{0.69}$$

$$n_2 = 1.45$$

[4 marks]
1 mark for reading x and y values from the graph (accept any valid point).
1 mark for calculating the gradient.
1 mark for interpreting the meaning of the gradient.
1 mark for providing substitution and calculations that lead to the correct answer.
(Note: Accept answers between 1.43 and 1.47.)
Note: Accept follow-through errors.

QUESTION 26 (6 marks)

For example, any one of:



[1 mark]

1 mark for showing and labelling the thrust force and weight force.

Note: Accept variations in the conventions used in the free body diagram. Accept a dot, square, picture or other suitable representation of the body. Accept any sensible labels for forces, including T, F_T, F_{tens} or similar to represent thrust.

$$\begin{aligned} F_{\text{net}} &= F_T - F_g \\ &= F_T - mg \\ &= 5370 - 800 \times 1.63 \\ &= 4066 \text{ N upwards} \end{aligned}$$

$$\begin{aligned} a &= \frac{F_{\text{net}}}{m} \\ &= \frac{4066}{800} \\ &= 5.0825 \\ &= 5.1 \text{ m s}^{-2} \end{aligned}$$

$$\begin{aligned} v^2 &= u^2 + 2as \\ (75)^2 &= (0)^2 + 2 \times 5.0825 \times s \\ s &= 553 \text{ m} \end{aligned}$$

[5 marks]

1 mark for the net force.

1 mark for using $F_g = mg$.

Note: This mark may be implied by subsequent working.

It is not required to state the formula.

1 mark for finding the acceleration.

1 mark for using $v^2 = u^2 + 2as$.

Note: This mark may be implied by subsequent working.

It is not required to state the formula.

1 mark for providing the correct answer.

Note: Accept follow-through errors.

QUESTION 27 (5 marks)

Converting 1.2 kiloohms to ohms gives:

$1.2\ \text{k}\Omega = 1200\ \Omega$

Finding the equivalent resistance gives:

$$R_E = \frac{1}{\frac{1}{470} + \frac{1}{1200} + \frac{1}{680}} + 560$$
$$= 786\ \Omega$$

Determining the current gives:

$$I = \frac{V}{R}$$
$$= \frac{15}{786}$$
$$= 0.019\ \text{A}$$
$$= 19\ \text{mA}$$

[5 marks]
1 mark for converting 1.2 kΩ to 1200 Ω.
1 mark for consolidating the parallel resistors.
1 mark for consolidating the series resistors.
1 mark for using Ohm's Law to find the current.
1 mark for converting the current from amps to milliamps.
Note: Accept follow-through errors.