QCAA ALTERNATIVE SEQUENCE
PHYSICS EXTERNAL EXAM – 2024
MULTIPLE CHOICE QUESTIONS - SOLUTIONS AND EXPLANATIONS

Dr Richard Walding, richard@walding.com
22 Nov 2024
Note: *NCPQ* refers to *New Century Physics for Queensland*, 2020, OUP.

Q		Solutions
1 AS	A*	Correct. This is the definition of power. Formula is P = W/t.
	B	Incorrect. This is the definition for resistance.
	C	Incorrect. This is the definition of efficiency.
	D	Incorrect. This is a variation of Kirchhoff's voltage law expressed in terms of conservation of energy in a circuit. It is true but irrelevant to the definition of power dissipation.
2 AS	A	Incorrect. The kinetic energy remains the same. It is the potential energy that increases.
	B	Incorrect. Kinetic energy would only decrease when the temperature is reduced.
	C*	Correct. Kinetic energy is related to temperature. If temperature remains constant, then the kinetic energy of the particles doesn't change.
	D	Incorrect. The nature of the substance is irrelevant.
3 AS	A	Incorrect. Used $10\times\left(\frac{150}{1.5}\right)^2=10^5$
	B	Incorrect. Used $10\times\frac{1.5}{150}=10^{-1}$
	C*	Correct. $I_1 r_1^2 = I_2 r_2^2$ $I_2 = I_1\left(\frac{r_1}{r_2}\right)^2$ $=10\times\left(\frac{1.5}{150}\right)^2 = 10\times(10^{-2})^2$ $=10^{-3}$ W m^{-2}
	D	Incorrect. Used faulty transposition of formula: $I_1 r_1^2 = I_2 r_2^2$ $I_2 = \frac{1}{I_1}\left(\frac{r_1}{r_2}\right)^2$ [*incorrect*] $=\frac{1}{10}\times\left(\frac{1.5}{150}\right)^2 = 10^{-1}\times(10^{-2})^2$ $=10^{-5}$ W m^{-2}

4 GS AS	A	Incorrect. Wave theory can explain diffraction (Experiment 1) but not the photoelectric effect (Experiment 2)
	B	Incorrect. This refers to refraction. The wave model does support refraction but is not related to Experiment 1. The particle model does support Newton's particle model but has refraction the wrong way around, and is not related to Experiment 2 anyway.
	C*	Correct. Experiment 2 correctly shows particle model but not wave model.
	D	Incorrect. This is irrelevant to Experiment 1 and 2. Gravitational waves can travel in a vacuum, but this is irrelevant to both experiments.
5 GS AS	A*	Correct. A statement of Coulomb's law $F = \frac{kQq}{r^2}$
	B	Incorrect. Misreading of Coulomb's law. The force actually decreases as the distance increases.
	C	Incorrect. Misreading of Coulomb's law. The force is actually inversely proportional to square of the distance.
	D	Incorrect. Coulomb's law actually says that it is inversely related.
6 AS	A	Incorrect. The electron accelerates towards positive plate and gains kinetic energy. This means it has lost electrical potential energy (law of conservation of energy).
	B*	Correct. As the kinetic energy of the electron increases it must be losing electrical potential energy.
	C	Incorrect. The symbol V is for electrical potential not electrical potential energy. They are related and the electron is experiencing a region of increasing electrical potential (from 0V to +12V). Its electrical potential energy is <u>decreasing</u> as it gains kinetic energy.
	D	Incorrect. The symbol V is for electrical potential not electrical potential energy. They are related and the electron is experiencing a region of increasing electrical potential (from 0V to +12V). Its electrical potential energy is <u>decreasing</u> as it gains kinetic energy.
7 AS	A	Incorrect. Specific latent heat is defined as "the amount of energy transfer necessary to change the state of <u>one kilogram</u> of a substance with no change in its temperature". QCAA Syllabus, 2019, Glossary, page 92. This option has neglected to say that it is for "1 kg"
	B	Incorrect. This is a measure of the heat transferred, ΔQ, other than during a phase change.
	C	Incorrect. This is the definition of specific heat capacity which is "the amount of thermal energy transfer necessary to raise the temperature of one kilogram of a substance by one degree" (not specific <u>latent</u> heat). See QCAA syllabus, 2019, Glossary page 92.
	D*	Correct. Specific latent heat is defined as "the amount of energy transfer necessary to change the state of one kilogram of a substance with no change in its temperature". QCAA Syllabus, 2019, Glossary, page 92. This option correctly says that it is for "1 kg" unlike Option A which doesn't mention the mass of 1 kg.
8 AS	A	Incorrect. Used the correct formula but didn't convert mass to kg.
	B	Incorrect. Used $Q = mL_v$ $L_v = Qm = (74-26)\times 0.25$ [*incorrect*] $= 12\,\text{kJ kg}^{-1}$ (2 s.f.)

	C*	Correct. Determined the heat added over the part of the curve where there was no temperature rise (at 60°C) as 74 – 26 kJ. This is where the substance is undergoing a phase change. A flat line could indicate a substance melting but the question says “a liquid”. $Q = mL_{\text{v}}$ $L_{\text{v}} = \frac{Q}{m} = \frac{74-26}{0.250} = \frac{48}{0.25}$ $=190\,\text{kJ}\,\text{kg}^{-1}\,(2\,\text{s.f.})$
	D	Incorrect. Didn’t determine the heat added during the phase change. Just used the final value. $Q = mL_{\text{v}}$ $L_{\text{v}} = \frac{Q}{m} = \frac{74}{0.250}\ [\textit{incorrect}]$ $= 296\,\text{kJ}\,\text{kg}^{-1}$ $=300\,\text{kJ}\,\text{kg}^{-1}\,(2\,\text{s.f.})$
9 AS	A	Incorrect. Used the closed pipe formula (incorrect) and identified the mode of vibration as $n = 1$ (incorrect): $L = (2n-1)\frac{\lambda}{4}$ $0.300 = (2\times 1-1)\frac{\lambda}{4}$ $\lambda = 0.300\times 4 = 1.20\,\text{m}$ $f = \frac{v}{\lambda} = \frac{346}{1.20} = 288\,\text{Hz}$
	B	Incorrect. Determined the wavelength incorrectly to be 2 × 30.0 cm = 6.00 cm = 0.600 m. $f = \frac{v}{\lambda} = \frac{346}{0.600} = 577\,\text{Hz}$ Alternatively, used the correct (open pipe) formula but determined the mode to be $n = 1$. $L = n\frac{\lambda}{2}(\textit{open pipe})$ $\lambda = \frac{2L}{1} = \frac{2\times 0.300}{1} = 0.600\,m$ (in *first* mode of vibration, $n = 1$] $= 0.600\,\text{m}$
	C	Incorrect. Determined the correct mode ($n = 2$) but incorrectly used the closed pipe formula instead of the open pipe formula:

$$L = (2n-1)\frac{\lambda}{4}$$

$$0.300 = (2 \times 2 - 1)\frac{\lambda}{4}$$

$$\lambda = \frac{0.300 \times 4}{3} = 0.400\,\text{m}$$

$$f = \frac{v}{\lambda} = \frac{346}{0.400} = 865\,\text{Hz}$$

D* Correct. The wave shown inside the pipe is one full wavelength (the solid line goes from trough at the left end to a trough at the right end with just the one crest in between, so it represents one wavelength. If 1λ = 0.300 m, and we know the speed of sound at 25°C in air is 346 m s^{-1} from the QCAA *Formula and data book*, then: $f = \frac{v}{\lambda} = \frac{346}{0.300} = 1150\,\text{Hz}$.

Alternatively:

$$L = n\frac{\lambda}{2} (open\ pipe)$$

$$\lambda = \frac{2L}{n} = \frac{2 \times 0.300}{2} = 0.300\,m \text{ (in second mode of vibration, } n = 2]$$

$$= 0.300\,\text{m}$$

$$f = \frac{v}{\lambda} = \frac{346}{0.300} = 1150\,\text{Hz}$$

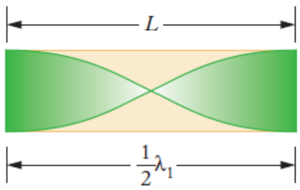
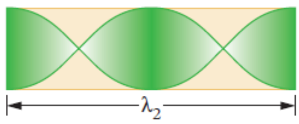
Standing wave pattern	L	λ	$f = \frac{v}{\lambda}$	f	Name	n
	$\frac{\lambda_1}{2}$	$\lambda_1 = 2L$	$f_1 = \frac{v}{2L}$	f_1	Fundamental frequency or first harmonic	1
	λ_2 or $\frac{2\lambda_2}{2}$	$\lambda_2 = L$	$f_2 = \frac{2v}{2L}$	$f_2 = 2f_1$	Second harmonic	2

Diagram from *New Century Senior Physics* U1&2, 2019, page 419.

10

A Incorrect. Used correct formula but didn't convert 86 cm to m.

B* Correct.

$$F = BIL\sin\theta = 0.0306\sin\theta$$

$$BIL = 0.0306$$

$$B = \frac{0.0306}{2.4 \times 0.85} = 0.015\,\text{T}$$

$$= 1.5 \times 10^{-2}\,\text{T}$$

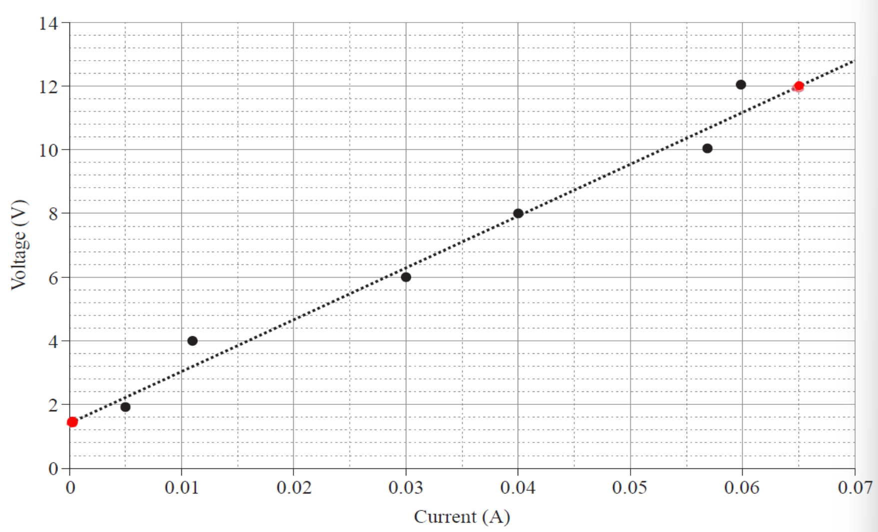
$$\text{O.M.} = 10^{-2}\,\text{T}$$

C Incorrect. Used correct formula and result of 0.015 T, and correctly said you had to multiply the answer by 10^2 to make it 1.5 but assumed that 10^2 was OM.

D Incorrect. Used correct formula but didn't convert 85 cm to 0.85 m and had a result of 0.00015 T which they said was 1.5×10^4 and an OM of 10^4.

11 AS	A	Incorrect. $T_C = T_K + 273$ [*incorrect*] $= 234.5 + 273 = 507.5^\circ C$
	B	Incorrect. $T_K = T_C + 273$ $T_C = 273 - T_K$ [*incorrect*] $= 273 - 234.5$ $= 38.5^\circ C$
	C*	Correct. $T_K = T_C + 273$ $T_C = T_K - 273$ $= 234.5 - 273$ $= -38.5^\circ C$
	D	Incorrect. $T_K = T_C + 273$ $T_C = -T_K - 273$ [*incorrect*] $= -234.5 - 273$ $= -507.5^\circ C$
12 AS	A	Incorrect. Used $W = \frac{VI}{t} = \frac{210 \times 1.7}{5.0 \times 60} = 1.2\,J$
	B	Incorrect. Used $W = VI = 210 \times 1.7 = 360\,J$
	C	Incorrect. Didn't convert minutes to seconds: $W = VIt = 210 \times 1.7 \times 5.0 = 1800\,J$
	D*	Correct. $W = VIt = 210 \times 1.7 \times 5.0 \times 60 = 110\,000\,J$
13 GS AS	A	Incorrect.
	B*	Correct. $E_{k(max)} = hf - W$ $W = hf - E_{k(max)}$ $= 6.626 \times 10^{-34} \times 9.4 \times 10^{15} - 5.6 \times 10^{-18}$ $= 6.28 \times 10^{-19}\,J$ $= \frac{6.28 \times 10^{-19}}{1.6 \times 10^{-19}}\,eV$ =3.9 eV
	C	Incorrect.
	D	Incorrect.
14 GS AS	A	Incorrect. Says $B \propto \frac{\Delta\phi}{A}$
	B*	Correct. Formula $B \propto \frac{\phi}{A}$

	C	Incorrect. Flux density is for 2-D area, not a 3-D space like volume
	D	Incorrect. This is the ratio used for interpreting deflections of a particle in a magnetic field. It is used in mass spectroscopy. Good examples in QCAA website Sample EA paper 2020 Paper 1 Q25, or 2020 EA Paper 2 Q6.
15 AS	A	Incorrect. This is referring to a system in which is likely to be highly efficient as there is no heat loss to the environment ($Q_{out} = 0$). That is, any heat added or work done on a system is converted into work done by the system without heat loss. However, this is not the definition of efficiency.
	B*	Correct. This is the definition of efficiency.
	C	Incorrect. This is referring to a system that is in thermal equilibrium and all components are at the same temperature with no transfer of energy between them.
	D	
16 AS	A*	Correct. $\frac{n_2}{n_1} = \frac{\lambda_1}{\lambda_2}$ $\frac{n_g}{n_w} = \frac{\lambda_w}{\lambda_g}$ $\lambda_g = \frac{\lambda_w n_w}{n_g} = \frac{555 \times 1.33}{1.5}$ $= 492\,\text{nm}$
	B	Incorrect. Not sure how this answer would be arrived at.
	C	Incorrect. Said there was no change in wavelength. Probably was thinking that there is no change in frequency (which is correct).
	D	Incorrect. Used: $\lambda_g = \frac{\lambda_w n_g}{n_w} = \frac{555 \times 1.5}{1.33}$ $= 625\,\text{nm}$
17 AS	A*	Correct. Choose two widely space data points that are on the line of best fit (as shown by red dots). Calculate the gradient of the line. The gradient equals the resistance. It is linear so the resistance doesn’t change over that range of voltages and currents.

		 $R=\frac{\Delta V}{\Delta I}=\frac{12.0-1.4}{0.065-0}=\frac{10.6}{0.065}=1.6\times10^{2}\ \Omega$
	B	Incorrect. This solution incorrectly just uses a single point on the line (eg the top red dot in the diagram above) and ignores the fact that it doesn't pass through the origin (0, 0). $R=\frac{V}{I}=\frac{12.0}{0.065}==1.8\times10^{2}\ \Omega$
	C	Incorrect. Has used the last data point (which is not on the line). $R=\frac{V}{I}=\frac{12.0}{0.060}==2.0\times10^{2}\ \Omega$
	D	Incorrect. Not sure how this value would have been obtained.
18 GS AS	A	Incorrect. They are not parallel but are perpendicular
	B	Incorrect. Have the same wavelength and thus same frequency and speed for each component
	C*	Correct. Definition in syllabus is "synchronised oscillations"
	D	Incorrect. Intersect at the base or equilibrium position of their components
19 GS AS	A	Incorrect. Probably said $OM=\frac{10^{-8}}{10^{-6}}=10^{-2}$
	B*	Correct. $V=\frac{\Delta U}{q}=\frac{W}{q}=\frac{1.5\times10^{-8}}{7\times10^{-6}}=2.14\times10^{-3}$ $OM=10^{-3}$ V Could also estimate by converting to OM first: $V(OM)=\frac{W}{q}=\frac{10^{-8}}{10^{-5}}=10^{-3}$ V
	C	Incorrect. Didn't use microcoulomb

		$V=\frac{W}{q}=\frac{1.5\times10^{-8}}{7}=2.14\times10^{-9}$ $OM=10^{-9}$ V
	D	Incorrect. Used $V = Wq$ and identified OM as 10^{-13} V
20 GS AS	A*	Correct. Definition of blackbody – see QCAA 2019 syllabus p 65
	B	Incorrect. Related to spectrum of light with two orbital transitions
	C	Incorrect. Related to the failure of wave theory in explaining photoelectric effect
	D	Incorrect. Related to Wein's displacement graph but is wrong anyway.

Whew! For other worked solutions to EA past papers see seniorphysics.com/ncpq