Neap

Trial Examination 2022

Suggested Solutions

QCE Physics Units 3&4

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.	○	●	○	○

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QUESTION 1 A

A is correct. Photons mediate the electromagnetic force.

B, **C** and **D** are incorrect. These options are the gauge bosons that mediate the strong and weak nuclear forces.

QUESTION 2 B

B is correct. Work function is equal to hf_o, which is the minimum energy required for the emission of a photoelectron.

A is incorrect. This option states 'maximum' rather than 'minimum'.

C is incorrect. The minimum kinetic energy that a photoelectron can have is 0 J regardless of the solid.

D is incorrect. This option is the definition of threshold frequency.

QUESTION 3 A

A is correct. In this diagram, the force upwards is the electrostatic force and the force downwards is gravity. These are equal and opposite. This would allow the foam ball to levitate.

B is incorrect. In this diagram, the force arrows point towards the object, which is incorrect.

C is incorrect. In this diagram, the forces are not balanced.

D is incorrect. This diagram does not take gravity into consideration.

QUESTION 4 D

D is correct.

$$\frac{V_p}{V_s} = \frac{n_p}{n_s}$$

$$\frac{240}{60} = \frac{n_p}{200}$$

$$n_p = 800 \text{ loops of wire}$$

A is incorrect. This option may be reached if one of the fractions is written the wrong way around (flipped).

B is incorrect. This option represents the difference in voltage between the primary and secondary coils at their peaks.

C is incorrect. This option may be reached by reading the voltage of the primary coil from the graph.

QUESTION 5 C

C is correct. As the number of incident photons is increased, the number of photoelectrons released increases as one photoelectron results from one photon. The wavelength of photons does not change, so the photoelectron energy does not change.

A and **B** are incorrect. These options suggest that photoelectron energy increases with light intensity; this is not observed in the photoelectric effect.

D is incorrect. While there is no change in photoelectron energy, the number of photoelectrons released increases.

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QUESTION 6 C

C is correct.

$$s = ut + \frac{1}{2}at^2$$

$$-100 = 0 + \frac{1}{2}(-9.8)t^2$$

$$t = 4.5 \text{ seconds}$$

A is incorrect. This option may be reached by calculating $\frac{30 \text{ m s}^{-1}}{100 \text{ m}}$.

B is incorrect. This option may be reached by calculating $\frac{100 \text{ m}}{30 \text{ m s}^{-1}}$.

D is incorrect. This option may be reached by calculating t^2.

QUESTION 7 B

B is correct. An elementary particle has no discernible parts that make it up (substructure).

A is incorrect. This option may be reached if elementary particles are incorrectly conceived as a 'pure' substance, like 'elements' of the periodic table.

C is incorrect. This option assumes that all subatomic particles are elementary; however, not all are. Protons and neutrons, which are composed of quarks, are not elementary.

D is incorrect. This option identifies examples of elementary particles but does not provide a definition.

QUESTION 8 D

D is correct.

$$\frac{T^2}{r^3} = \frac{4\pi^2}{GM}$$

$$2.97 \times 10^{-19} = \frac{4\pi^2}{6.67 \times 10^{-11} \times M}$$

$$M = 2.0 \times 10^{30} \text{ kg}$$

A is incorrect. This option may be reached if one of the fractions is written the wrong way around (flipped).

B is incorrect. This option may be reached if the $\times 10^{-19}$ factor is not considered.

C is incorrect. This option may be reached if π is not squared.

QUESTION 9 D

D is correct. Magnetic field lines leave north poles and enter south poles. As such, pole 1 is north, pole 2 is south and pole 3 is north.

A is incorrect. This option may be reached by assuming field lines enter north poles and leave south poles.

B is incorrect. This option may be reached by confusing poles 2 and 3.

C is incorrect. This option may be reached by assuming field lines enter north poles and leave south poles, and confusing poles 2 and 3.

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QUESTION 10 C

C is correct.

$$p_v = \frac{m_0 v}{\sqrt{\left(1-\frac{v^2}{c^2}\right)}}$$

$$= \frac{(1.88\times10^{-28})(0.995)(3\times10^8)}{\sqrt{\left(1-\frac{(0.995c)^2}{c^2}\right)}}$$

$$= \frac{(1.88\times10^{-28})(0.995)(3\times10^8)}{\sqrt{(1-0.995^2)}}$$

$$= 5.62\times10^{-19} \text{ kg m s}^{-1}$$

A is incorrect. This option may be reached by not considering c in the numerator and not squaring 0.995 in the denominator.

B is incorrect. This option may be reached by not considering the c in the numerator.

D is incorrect. This option may be reached by not squaring 0.995 in the denominator.

QUESTION 11 D

D is correct. Since $\Delta E = mc^2$, ΔE is directly proportional to Δm.

A is incorrect. While this statement is true, it does not relate to the mass–energy equivalence relationship.

B is incorrect. This option describes the incorrect relationship $\Delta m = \Delta Ec$.

C is incorrect. This option describes the incorrect relationship $\Delta m = \Delta Ec^2$.

QUESTION 12 D

D is correct. Horizontal velocity is constant, remaining at 25 m s^{-1}. Vertical velocity starts at 0 m s^{-1} and accelerates at –9.8 m s^{-1} per second; after 1.0 second, it is –9.8 m s^{-1}, and after 2.0 seconds, it is –19.6 m s^{-1}.

A is incorrect. This option shows the speed after 1.0 second. It may be mistaken for acceleration due to gravity.

B is incorrect. This option assumes the rock is accelerating horizontally and vertically.

C is incorrect. This option assumes the rock is accelerating horizontally only.

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QUESTION 13 D

D is correct.

$$T = \frac{\text{time}}{\text{revolutions}}$$
$$= \frac{5}{10}$$
$$= \frac{1}{2} \text{ s}$$

$$v = \frac{2\pi r}{T}$$
$$= \frac{2\pi r}{\frac{1}{2}}$$
$$= 4\pi r$$

A is incorrect. This option may be reached if an incorrect period of 2 seconds is used.

B is incorrect. This option may be reached if an attempt is made to apply the equation $a_c = \frac{v^2}{r}$ and square-root to obtain velocity.

C is incorrect. This option may be reached if the final fraction is cancelled down incorrectly.

QUESTION 14 D

D is correct. As shown in the Formula and Data Booklet, Faraday's law is $\text{emf} = -n\frac{\Delta\phi}{\Delta t}$. This shows the rate of change of magnetic flux and the number of coils of wire that the flux crosses on the right-hand side, and electromotive force on the left-hand side.

A is incorrect. This option represents Lenz's law.

B is incorrect. This option represents an incorrect version of Lenz's law. It states that the change in flux is enhanced rather than opposed.

C is incorrect. This option represents an incorrect version of Faraday's law. It uses the word 'electromagnetic' rather than 'electromotive'.

QUESTION 15 C

C is correct. A meson contains a heterogenous particle/antiparticle pair of quarks. A baryon contains three quarks or three antiquarks.

A is incorrect. The first quark pair does not have an antiparticle, so it cannot be a meson.

B is incorrect. This option shows a baryon and an antibaryon.

D is incorrect. The second quark triple does not fit the definition of a baryon.

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QUESTION 16 B

B is correct. As $E = hf$, the gradient must be $\frac{E}{f}$. Thus, the y-axis must be E (energy). **B** is the only option that is a measurement of energy. E_k refers to the kinetic energy of the photoelectron when a photon is completely absorbed by an electron in the photoelectric effect.

A, **C** and **D** are incorrect. These options are concepts related to the photoelectric effect. They produce valid graphs related to the photoelectric effect, but their gradients do not represent Planck's constant.

QUESTION 17 B

B is correct. Lepton and baryon numbers are conserved in particle interactions.

A is incorrect. A pion is a specific type of lepton; there is no pion number.

C is incorrect. There is no gauge number.

D is incorrect. Particle and antiparticle numbers are not conservation quantities.

QUESTION 18 B

B is correct.

$$\lambda_e = \lambda_p$$

$$\frac{h}{p_e} = \frac{h}{p_p}$$

$$p_e = p_p$$

$$(mv)_e = (mv)_p$$

$$\therefore v_e = \frac{(mv)_p}{m_e}$$

$$= \frac{1.6726219 \times 10^{-27} \times 2.8 \times 10^4}{9.1093835 \times 10^{-31}}$$

$$= 5.1 \times 10^7 \text{ m s}^{-1}$$

A is incorrect. This option may be reached if only the non-exponents math is calculated.

C is incorrect. This option may be reached by rounding off incorrectly.

D is incorrect. This option may be reached if only the exponents math is calculated.

QUESTION 19 C

C is correct. Acceleration is change in velocity, and the direction of the acceleration in uniform circular motion is always inwards (towards the centre of curvature).

A and **B** are incorrect. These options refer to force, not acceleration.

D is incorrect. This option states the wrong direction.

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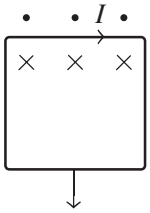
QUESTION 20 B

B is correct. Lenz's law states that the induced current in the loop of wire will produce a magnetic field that opposes the change in flux inside the loop. Since the loop is being pulled out of the external magnetic field, the magnetic flux inside the loop will decrease. According to Lenz's law, the induced current will act to increase the magnetic flux inside the loop, which means the induced magnetic field will act to enhance the external magnetic field. If the top section of the loop of wire is considered only, using the right-hand grip rule, the induced current must be towards the right of the page (that is, clockwise) in order to increase the flux on the inside of the loop.



A is incorrect. This option has the direction of the external magnetic field reversed. This option may be reached if a mistake is made with either the in/out notation or by using the wrong hand for the hand rule.

C and **D** are incorrect. These options are rotations of the same physical situation. Both options show the loop of wire entering the field, which is the opposite of the situation for option **B**.

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SECTION 2

QUESTION 21 (1 mark)

1. up (u)
2. down (d)
3. charm (c)
4. strange (s)
5. top (t)
6. bottom (b)

[1 mark]
1 mark for listing all six quarks.
Note: Quarks may be listed in any order. Listing the symbols in addition to, or in place of, quark names is permitted. If both are provided, then the symbol must match the name. Listing the respective antiparticles is permitted but only in addition to, not in place of, the quarks listed in the sample response. Misspelling of quark names is permitted if the error does not impede meaning.

QUESTION 22 (2 marks)

c OR 3×10^8 m s^{-1}

Light travels at a constant speed in a vacuum in all inertial frames of reference.

[2 marks]
1 mark for stating the correct speed.
1 mark for providing justification.
Note: Justification must include all of the following to be awarded the mark: constant speed, 'in a vacuum', all inertial frames of reference (or non-accelerating frames of reference).

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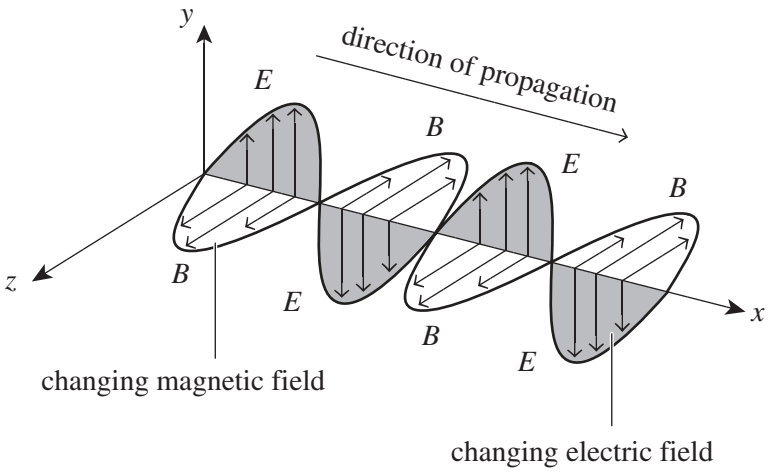
QUESTION 23 (3 marks)

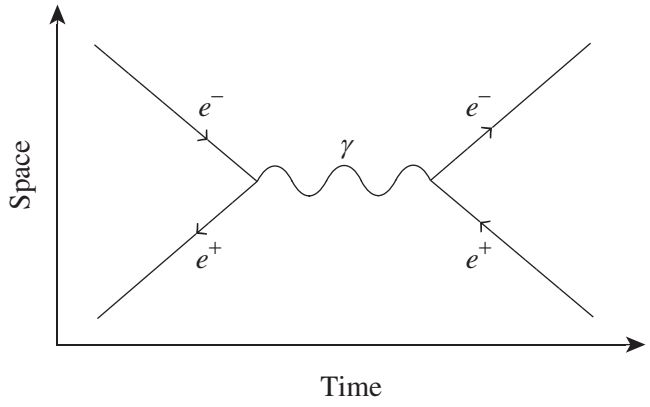
For example:

Electromagnetic radiation is energy that travels/propagates through mutually perpendicular (that is, in-phase) oscillating electric and magnetic fields.



[3 marks]
1 mark for stating that energy travels/propagates.
1 mark for stating that the fields are perpendicular.
1 mark for stating that the fields are in-phase (or mutual).
Note: A combination of a diagram and written response may be awarded full marks.
Responses must include all correct concepts.

QUESTION 24 (3 marks)



[3 marks]
1 mark for labelling all five particles (words or symbols).
1 mark for showing all arrows in the correct directions.
1 mark for showing correct orientation (drawn as shown to axes provided).
Note: Responses that show incorrect orientation can still be awarded the other marks.

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QUESTION 25 (3 marks)

$$L = L_0\sqrt{1-\frac{v^2}{c^2}}$$

$$26 = 30\sqrt{1-\frac{v^2}{c^2}}$$

$v = 0.5c$ (to 1 decimal place)

[3 marks]

1 mark for recognising either $L = 26$ m or $L_0 = 30$ m.

1 mark for substituting into the formula.

1 mark for calculating the speed.

QUESTION 26 (6 marks)

$$\bar{E}_{\text{Q}} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$$

$$= \frac{1}{4\pi\varepsilon_0}\frac{5\times10^{-6}}{0.05^2}$$

$$= 1.8\times10^{7}\ \text{N C}^{-1} \text{ down the page}$$

$$\bar{E}_{\text{R}} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$$

$$= \frac{1}{4\pi\varepsilon_0}\frac{2\times10^{-6}}{0.05^2}$$

$$= 7.2\times10^{6}\ \text{N C}^{-1} \text{ up the page}$$

$$\text{resultant } \bar{E} \text{ at midpoint} = \left(1.8\times10^{7}\right) + \left(-7.2\times10^{6}\right)$$

$$= 1.1\times10^{7}\ \text{N C}^{-1} \text{ down the page}$$

[6 marks]

1 mark for converting μC to C.

1 mark for using 5 cm or 0.05 m for radius.

1 mark for calculating $\bar{E}_{\text{Q}}$ (direction not required).

1 mark for calculating $\bar{E}_{\text{R}}$ (direction not required).

1 mark for calculating the magnitude.

1 mark for determining the direction.

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QUESTION 27 (3 marks)

Any three of:

- A photon is a quantum of energy in the form of electromagnetic radiation.
- A photon has no mass.
- A photon has momentum.
- A photon travels at c, or 3×10^8 m s^{-1}, in a vacuum.
- A photon is the particle form of light distinct from the wave model of light.
- A photon is a gauge boson that is the mediating particle for the electromagnetic force.

[3 marks]

1 mark for each correct characteristic.

Note: If a response states that photons travel at c, or 3×10^8 m s^{-1}, the response must also state 'in a vacuum'.

QUESTION 28 (4 marks)

At the Earth's surface:

$$g_E = \frac{Gm_E}{r_E^2}$$

$$9.8 = \frac{6.67 \times 10^{-11} \times 5.97 \times 10^{24}}{r_E^2}$$

$$r_E = 6.3744 \times 10^6 \text{ m}$$

Adding 400 km to this radius gives:

$$r_{ISS} = 6.3744 \times 10^6 + 400\,000$$

$$= 6.7744 \times 10^6 \text{ m}$$

g at the ISS:

$$g_{ISS} = \frac{Gm_E}{r_{ISS}^2}$$

$$= \frac{6.67 \times 10^{-11} \times 5.97 \times 10^{24}}{\left(6.7744 \times 10^6\right)^2}$$

$$= 8.6768 \text{ m s}^{-2}$$

Gravitational force acting on the combined mass:

$$F_g = mg$$

$$= 100 \times 8.6768$$

$$= 868 \text{ N}$$

$$\approx 870 \text{ N (to 2 significant figures)}$$

[4 marks]

1 mark for calculating the radius of Earth. (Note: Scientific notation not required. Accept values in the range 6.37–6.40 $\times 10^6$ m.)

1 mark for calculating the radius of the ISS. (Note: Scientific notation not required. Accept values in the range 6.77–6.80 $\times 10^6$ m.)

1 mark for calculating g_{ISS}. (Note: Accept values in the range 8.61–8.69 m s^{-2}.)

1 mark for calculating the gravitational force. (Note: Accept values in the range 860–870 N.)

Note: Accept follow-through errors.

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