Neap:

Trial Examination 2012

VCE Physics Unit 1

Written Examination

Suggested Solutions

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AREA OF STUDY 1 – NUCLEAR PHYSICS AND RADIOACTIVITY

Question 1

Each isotope varies in the number of neutrons. 1 mark

Question 2

Oxygen-15 1 mark

Use the mass number. It has 7 neutrons and 8 protons (15 – 8 = 7). 1 mark

Question 3

Artificial isotopes are man-made, for example in the laboratory or nuclear reactor 1 mark

whereas natural isotopes occur in nature and are found in the air, rocks, etc. 1 mark

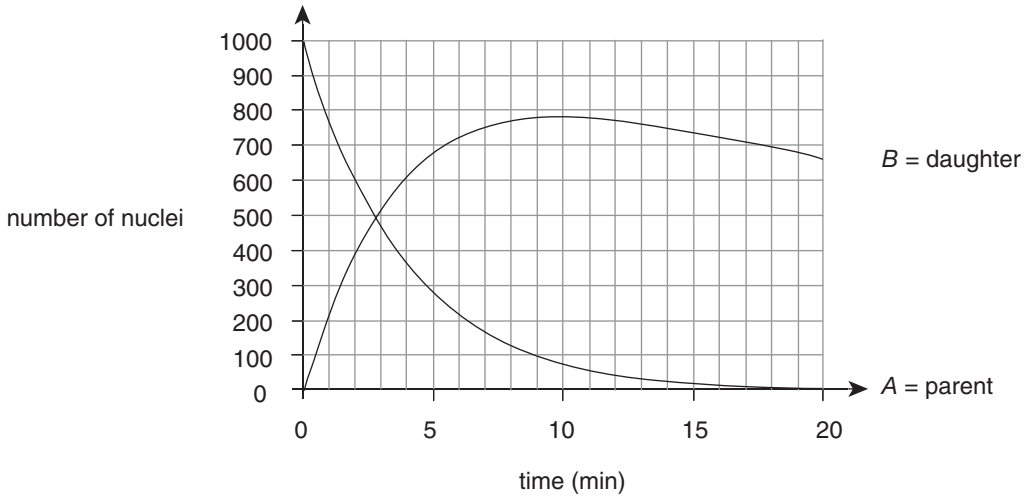
Question 4

Yes, it is radioactive. 1 mark

It emits a particle of some type (and photon/light energy – optional to mention this), which in this case is a positron. 1 mark

Accept any reasonable explanation, for example, if one element changes to another element, as in this case, this can only happen if the element is radioactive

Question 5



Labelling graphs *A* and *B* correctly. 1 mark

Graph *A* starts at 1000 and decreases while 1 mark

graph *B* starts at zero and increases, hence *A* must be the parent and *B* the daughter nucleus. 1 mark

Question 6

From the graph, the half-life is 2.5 minutes (accept 2.5 – 3 minutes). 1 mark

Question 7

Four half-lives. 1 mark

Explanation needs to show either some calculation, for example $\frac{1}{16} = (0.5)^4 = 4$ half-lives

or something like $0.5 \times 0.5 \times 0.5 \times 0.5$ 1 mark

Question 8

Graph *B* 1 mark

Graph *B* increases until about the 10 minute mark then starts to decay. This is longer in time than graph *A*.

OR

Graph *B* starts to decay after 10 minutes. At the 14 minute mark half of number of nuclei have not decayed. 1 mark

Question 9

A and *B* are both β^- particles. 2 marks

1 mark for each correct response

Question 10

A neutron has decayed into a proton and electron. 1 mark

The nucleus has ejected the electron. 1 mark

Question 11

Absorbed dose = $\frac{\text{dose equivalent}}{\text{quality factor}} = \frac{5}{1} = 5$ mGy 1 mark

Energy absorbed = absorbed dose × mass = 5 mGy × 65 = 0.325 J 1 mark

Question 12

662 keV = 662 000 eV 1 mark

Energy = $662\,000 \times 1.6 \times 10^{-19} = 1.06 \times 10^{-13}$ J 1 mark

Question 13

The energy = 400 Gy × 0.25 kg = 100 J 1 mark

The number of atoms required $= \frac{\text{energy}}{\text{energy per disintegration}}$ 1 mark

$$= \frac{100}{1.06 \times 10^{-13}}$$

$$= 9.4 \times 10^{14}$$

1 mark

Note: consequential on Question 12

Question 14

β-particles are electrons and are made of matter 1 mark

while γ-rays are high energy electromagnetic radiation (or light). 1 mark

Question 15

An α-particle ionises much more readily and would damage internal body cells. 1 mark

It also has low penetration and would not pass out of the body and be detected. 1 mark

A γ-ray has high penetration and interacts much less with matter and so can be more readily detected outside the body. 1 mark

Question 16

$U^{238} \rightarrow Th^{234} + He^{4} + \text{energy}$ 2 marks

Need to include energy or gamma-ray,
α instead of He is also acceptable

Question 17

	Atomic number			
Neutron number	**89**	**90**	**91**	**92**
146			α	U-238 4.5×10^{9} years
144		Th-234 24 days		
143		β^-	Pa-234 6.7 hours	
142			β^-	U-234 250 000 years

1 mark for each correct label

Question 18

4.5×10^{9} years 1 mark

With one-half life completed, it is expected 50% of U-238 would remain. 1 mark

AREA OF STUDY 2 – ELECTRICITY

Question 1

The kitchen appliances in Tom's kitchen exceeded 15 A when Tom turned the toaster on. 1 mark

This caused the fuse to break and the supply of current to be cut. 1 mark

This would happen because too much current in the wiring of the house can lead to fire. 1 mark

Question 2

Total current from microwave and kettle:

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

$$\frac{(1500 + 1800)}{240} = 13.75 \text{ A}$$ 1 mark

Current remaining until 15 A is reached = 1.25 A 1 mark

Minimum power: 240 V × 1.25 A = 300 W 1 mark

Question 3

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

$$= \frac{240}{13.75}$$ 1 mark

$$R = 17.5\ \Omega$$ 1 mark

Question 4

Live: this pin provides the current. 1 mark

Neutral: provides a pathway to complete the circuit. 1 mark

Earth: Provides a direct connection from the casing of the toaster to the earth. This is a safety device that reduces the effects if anyone touches a live casing of a faulty toaster. 1 mark

Question 5

$$E = P \times t$$

$$E = 1500 \text{ W} \times 1.5 \times 3600 \text{ s}$$

$$E = 8.1 \times 10^6 \text{ J}$$ 1 mark

E (in kWh) = P (in kW) × t (in h)

$$E = 1.5 \times 1.5$$

$$E = 2.25 \text{ kWh}$$ 1 mark

Question 6

$$I = \frac{P}{V} = \frac{24}{12}$$ 1 mark

$I = 2\text{A}$ 1 mark

Question 7

$E = P \times t = V \times I \times t$

$E = 12 \text{ V} \times 40 \text{ A} \times 3600 \text{ s}$ 1 mark

$E = 1.7 \times 10^6 \text{ J}$ 1 mark

Question 8

$E = V \times I \times t$

$1.7 \times 10^6 \text{ J} = 12 \text{ V} \times 8 \text{ A} \times t$ 1 mark

$t = 18000 \text{ s} (5 \text{ hrs})$ 1 mark

Question 9

$0.5 \times 0.25 \times 0.25 = \frac{1}{R_{eff}}$ 1 mark

$R_{eff} = 1 \ \Omega$ 1 mark

Question 10

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

$= \frac{6}{1}$

$= 6 \text{ A}$ 1 mark

Question 11

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

$I = \frac{6}{4}$ 1 mark

$I = 1.5 \text{ A}$ 1 mark

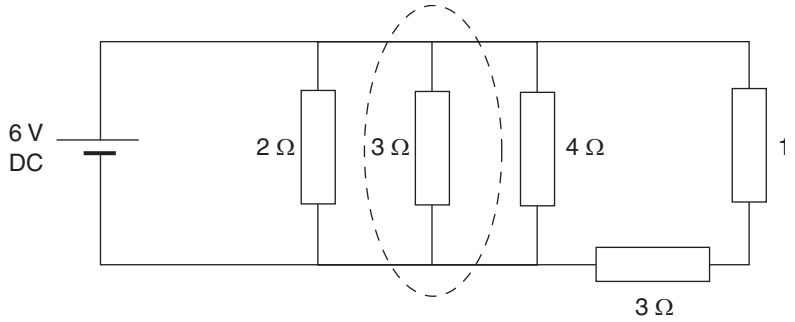
Question 12

$P = I^2 \times R$

$P = 1.5^2 \times 1$ 1 mark

$P = 2.25 \text{ W}$ 1 mark

Question 13



2 marks
1 mark for diagram correctly drawn fully connected
1 mark for parallel to circuit as shown

AREA OF STUDY 3 – DETAILED STUDIES (2 marks for each correct answer)

Detailed study 1 – Astronomy

Question 1 **B**

The horizon is altitude 0°.

Due West is azimuth 270°.

Question 2 **C**

Zenith in Melbourne is always declination –38°.

Question 3 **B**

Right ascension and declination are fixed references, independent of the motion of the Earth.

Question 4 **A**

Earth centred without epicycles – Aristotle's system.

Question 5 **D**

Retrograde motion of Mars is a result of the Earth overtaking its slower outer neighbour.

Question 6 **C**

Only correct option.

Question 7 **C**

The Sun and the Moon have a very similar angular diameter and therefore look the same in size.

Question 8 **D**

Neptune and Uranus cannot be seen with the naked eye.

Question 9 **A**

The very low energies involved in radio astronomy is one reason why radio telescopes have to be so large. (The other is that, given the long wavelengths involved, a large diameter telescope is needed to achieve sufficient resolution.)

Question 10 **C**

One of Galileo's contributions to astronomy was to show that the Moon and planets were quite similar to Earth. This opened up the possibility that Earth itself is just another planet.

Question 11 **D**

Venus achieves a greater time difference between sunset and its own setting time than Mercury. This means it must a have a greater orbital radius than Mercury. The data shows that Venus has a longer period (greater than 250 days) than Mercury (smaller than 250 days).

Question 12 **D**

All answers **A** to **C** are valid reasons.

Detailed study 2 – Astrophysics

Question 1 **D**

The parsec is 3.086×10^{16} m, the light-year is 9.461×10^{15} m, the AU is 1.496×10^{11} m, the Giga-metre is 1×10^{9} m.

Question 2 **B**

The photosphere produces the majority of the visible light.

Question 3 **A**

The principal reaction involves the fusion of hydrogen nuclei to form helium.

Question 4 **D**

Hotter stars have more visible light in the blue part of the spectrum.

Question 5 **C**

Total energy can be calculated by multiplying the energy per square metre multiplied by the surface area at the Earth's distance.

$$\text{Energy} = 1370 \times 4\pi \times (150 \times 10^{9})^{2}$$
$$= 3.9 \times 10^{26} \text{ W}$$

Question 6 **D**

The change in wavelength is known as redshift.

Question 7 **A**

The redshift meant that the galaxy was moving away from us.

Question 8 **B**

The universe has been expanding and so was a lot smaller in the past.

Question 9 **A**

The Milky Way is a spiral-type galaxy.

Question 10 **C**

The Sun is on the main sequence line in the middle approximately.

Question 11 **A**

Betelgeuse is cooler than Rigel.

Question 12 **D**

Both are in the super giant region.

Detailed study 3 – Energy from the nucleus

Question 1 **D**

Electrons do not account for the majority of the mass.

Question 2 **A**

Nucleons are held together by the strong nuclear force.

Question 3 **A**

At *A*, the strong nuclear force operates, while at *B*, electrostatic forces dominate.

Question 4 **D**

All three are requirements for fusion to occur.

Question 5 **C**

Use the mass number $1 + (239 - 94) = 145 - 56 + 93 - 38 + X$, rearranging to solve gives $X = 2$.

Question 6 **B**

Using $E = mc^2 = 3.07 \times 10^{-28}(3 \times 10^8)^2 = 2.763 \times 10^{-11}$ J.

Now number of reactions = $\dfrac{80 \text{ J}}{2.763 \times 10^{-11}} = 2.9 \times 10^{12}$ reactions per second.

Hence for one minute = $60 \times 2.9 \times 10^{12} = 1.7 \times 10^{14}$.

Question 7 **B**

The fragments have gained kinetic energy.

Question 8 **A**

A is the most correct as a greater number of neutrons (when compared to protons) are needed to stabilise larger elements.

Question 9 **B**

Neutrons are required to maintain a chain reaction. The flattened shape allowed too many neutrons to escape and not be captured by other U-235 atoms.

Question 10 **D**

Fastbreed reactors need fast moving neutrons and so do not need a moderator.

Question 11 **A**

U-235 will undergo fission by absorption of slow-moving neutrons.

Question 12 **C**

High-level waste generates large amounts of heat. This requires cooling and so this waste is stored in ponds of water.

Detailed study 4 – Investigations: Flight

Question 1 **D**

Both are incorrect. Assume that lift force is perpendicular to the 'upper' wing surface and therefore perpendicular to the plane's flight path.

As shown in the diagram above, this means that some of the weight force (that is, the component parallel to the plane's flight path) must be compensated for by an increase in thrust.

Hence, thrust is greater than drag (so statement I is incorrect) and lift is less than weight (so statement II is incorrect). Therefore the correct answer is **D**.

Question 2 **C**

$$\frac{(m \times g \times h)}{t} = \frac{(2 \times 106 \times 300)}{5} = 1.2 \times 10^8 \text{ W}$$

Question 3 **A**

$$P = F \times v$$

$$v = \frac{5 \times 10^7 \text{ W}}{2.0 \times 10^5 \text{ N}}$$

$$v = 250 \text{ m s}^{-1}$$

Question 4 **C**

$$\frac{\text{lift}}{\text{drag}} = \frac{2.0 \times 10^6 \text{ N}}{2.0 \times 10^5 \text{ N}} = 10$$

Question 5 **D**

Induced drag is a direct result of lift and can therefore not be reduced without losing lift.

Question 6 **B**

Decrease. The lift will increase as the wind speed increases so the weight indicated on the force meter will decrease.

Question 7 **B**

The dependent variable is the variable that changes in response to the changes that the experimenter makes.

Question 8 **C**

Both the change in momentum and Bernoulli's pressure difference combine to provide lift.

Question 9 **D**

Beyond a certain critical angle, the wing will stall, losing lift rapidly.

Question 10 **A**

Decreasing the drag on the left wing will ensure the net forward force on that wing increases, turning the plane to the right.

Question 11 **A**

$$\text{L1} + \text{L2} = \text{weight}$$

$$800\,000 \text{ N} + \text{L2} = 1 \times 10^6 \text{ N}$$

$$\text{L2} = 2.0 \times 10^5 \text{ N}$$

Question 12 **C**

Net torque about the centre of mass must be zero.

Detailed study 5 – Investigations: Sustainable energy sources

Question 1 **D**

Hot rocks will eventually cool when the heat is extracted from them. This might take several hundred years depending on the rock used. This heat will slowly replenish due to radioactivity, however, this will happen much slower than the rate of extraction. This makes hot rock geothermal a sustainable resource but not renewable. Wind is renewable because it is a direct result of the solar energy interacting with the Earth's atmosphere.

Question 2 **B**

$2 \times 4000 \times 10^3 \times 120 \times 10^3 = 96 \times 10^9$ W

Question 3 **D**

A typical coal fired power station might produce 2 GW.

Question 4 **B**

Wave power is proportional to the square of the wave amplitude. So wave height greatly affects the power. Wave height is mostly determined by wind.

Question 5 **D**

The lack of greenhouse gases makes wind an environmentally friendly energy source.

Question 6 **D**

Only correct option.

Question 7 **B**

$0.2 \times 1000 \times 0.12 = 24$ W

Question 8 **C**

$0.03 \text{ kg} \times 1.5 \text{ m} \times 10 = 0.45$ J

$$\frac{0.45 \text{ J}}{15 \text{ J}} = 0.03$$

$0.03 \times 100\% = 3\%$

Question 9 **C**

A turbine to turn the kinetic energy into rotational energy; a generator to turn the rotational energy into electricity; a battery to store the electric energy.

Question 10 **A**

$50 \times 10 \times 1.5 = 750$ J

Question 11 **C**

There is $2^3 = 8$ times more energy on Monday.

Question 12 **C**

Australia has plentiful supplies of solar energy, much more than our current total energy usage. So this is not a good reason why we are using so little.

Detailed study 6 – Medical physics

Question 1 **C**

Using $v = \frac{Z}{\rho} = \frac{1.38 \times 10^6}{900} = 1533.3 \text{ m s}^{-1} = 1.5 \times 10^3 \text{ m s}^{-1}$

Question 2 **A**

Substituting for v gives $Z = \rho\lambda f$ so as λ decreases (shortens) in value, then Z also decreases.

Question 3 **B**

Ultrasounds are used when scanning a foetus.

Question 4 **C**

MRIs typically produce 'slices' of the body.

Question 5 **D**

Women are not advised to have X-rays while pregnant.

Question 6 **A**

Hard X-rays have greater energy and hence penetrating power through the body than soft X-rays.

Question 7 **A**

Iodine-131 has a short half-life and produces γ-emissions which are detectable.

Question 8 **C**

Cobalt-60 produces γ-emissions solely that can penetrate tissue.

Question 9 **C**

PET relies on the production of positrons.

Question 10 **A**

MRIs produce strong magnetic fields that can interfere with electrical equipment.

Question 11 **B**

The light rays are totally internally reflected.

Question 12 D

The light bundle does not need to be coherent while the image needs to be coherent.

