Neap:

Trial Examination 2011

VCE Physics Unit 1

Written Examination

Suggested Solutions

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AREA OF STUDY 1 – NUCLEAR PHYSICS AND RADIOACTIVITY

Question 1

Example A is **Beta** decay because:

The mass number does not change and/or the atomic number increases by one. 1 mark

Example B is **Gamma** decay because:

The mass number **and** atomic number do not change. 1 mark

Example C is **Alpha** decay because:

The mass number (–4) **and** atomic number (–2) change. 1 mark

Students must give the correct decay mode and correct reason for each example to earn each mark

Question 2

The student's statement is wrong because the two nuclei of Cobalt have the same mass number. 1 mark

Isotopes have a different mass number. 1 mark

Question 3

$^{131}_{53}\text{I} \rightarrow {}^{131}_{54}\text{Xe} + {}^{0}_{-1}\text{e}$ 1 mark

Question 4

Tellurium-130 captures a neutron to become Te-131. 1 mark

This isotope of Tellurium is radioactive and decays via Beta decay to become I-131. 1 mark

One correct equation given

e.g. $^{130}_{52}\text{Te} + {}^{1}_{0}\text{n} \rightarrow {}^{131}_{52}\text{Te}$ or $^{131}_{52}\text{Te} \rightarrow {}^{131}_{53}\text{I} + {}^{0}_{-1}\beta$ 1 mark

Question 5

25% of the original isotope left means two half lives. 1 mark

17 days = 2 half lives, therefore 1 half-life = 8.5 days 1 mark

Question 6

1. Activity of the sample 1 mark
2. Mass of the patient 1 mark
3. Energy per beta particle 1 mark
4. Quality factor of the I-131 Beta radiation 1 mark

Question 7

$\left(\frac{\text{activity} \times \text{energy}\beta}{\text{mass of patient}}\right)$ to get absorbed dose 1 mark

Multiply absorbed dose by Quality Factor 1 mark

Question 8

Gamma rays can move through skin and can also move through several meters of air. 1 mark

Therefore, by keeping the distance between Andrea and other people quite large, it will reduce the amount of radiation the public will be exposed to. 1 mark

Question 9

With a half-life of 8.5 days 1 mark

the activity will have significantly reduced by 14 days. 1 mark

Question 10

The rock emits at least two types of radiation. 1 mark

One type must be Alpha, since it is readily shielded by sheets of paper. 1 mark

The other must be Beta, because it is affected only weakly by the paper. 1 mark

Gamma rays would not be affected by the paper at all. 1 mark

Question 11

Inhaling Alpha radiation sources is bad news: it is highly ionising 1 mark

and by inhaling it, the alpha particles can impact directly onto the living tissues in the lung. 1 mark

As a safety measure, she could have used a dust mask. 1 mark

Question 12

The remaining radiation is background radiation from other sources. 1 mark

Question 13

A decay chain is a series of decay events that happen when a radioactive isotope decays to form a daughter isotope, which itself is also radioactive. 1 mark

If the granddaughter is also radioactive, we call the resulting series of decay events a 'decay chain'. 1 mark

Question 14

When alpha decay happens a large chunk of nuclear material leaves the nucleus. As a result, the nucleus becomes unstable. 1 mark

When the nucleons reorganise themselves into a lower energy, more stable state, the energy difference is emitted as gamma radiation. 1 mark

Question 15

Rn-218 emits α particle to become Po-214.

Po-214 emits α particle to become Pb-210.

Pb-210 emits β particle to become Bi-210.

Bi-210 emits β particle to become Po-210.

Po-210 emits α particle to become Pb-206.

1 mark for correct use of β decays

1 mark for correct use of α decays

1 mark for correct sequence of decay events

Question 16

It is wrong because:

Any genetic change would only occur in the next generation, not to the person involved (or other reasonable argument). 1 mark

It is believable because:

Ionising radiation can cause genetic change/mutations (or other reasonable argument). 1 mark

AREA OF STUDY 2 – ELECTRICITY

Question 1 **B**

The positively charged particle will move towards the negatively charged plate. 2 marks

Question 2 **A**

Movement of charged particles over time is known as current. 2 marks

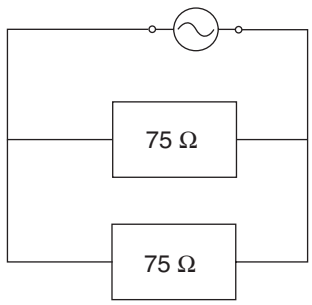
Question 3

AC stands for alternating current. 1 mark

The current reverses direction 50 times a second (not necessary to state period). 1 mark

Question 4

A parallel circuit gives the highest power output. Correct completion of the circuit:



2 marks

Question 5

A parallel circuit gives the lowest overall (effective) resistance. 1 mark

Lower resistance means more current and hence more power output. 1 mark

Question 6

The highest circuit is obtained by having the two resistors in parallel.

$$R_{\text{total}} = \left(\frac{1}{75} + \frac{1}{75} \right)^{-1} = 37.5\ \Omega$$ 1 mark

$$I = \frac{V}{R}$$
$$= \frac{240}{37.5}$$
$$= 6.4\ \text{A}$$
$$P = VI$$
$$= 240 \times 6.4$$
$$= 1536 \approx 1.5\ \text{kW}$$ 1 mark

Or can use:

$$P = \frac{V^2}{R}$$
$$= \frac{240^2}{37.5}$$
$$= 1.5\ \text{kW}$$

Question 7

The metal kettle has a conductive outer casing. This could become 'live' if there is a fault in the wiring and someone could electrocute themselves. 1 mark

The plastic casing is non-conductive and cannot become 'live'. 1 mark

Question 8

1 hr = 3600 s

$$Q = It = 0.6 \times 3600$$
$$= 2160\ \text{C}$$
$$= 2.2\ \text{kC}$$ 2 marks

Question 9

$$V = \frac{E}{Q}$$
$$= \frac{2600}{2160}$$
$$= 1.2\ \text{V}$$ 2 marks

Question 10

If the wiring is in series, all lights will have to be on at the same time – a situation which is often not required. 1 mark

If one light fails, all others will go out as well as the circuit is now broken. 1 mark

Question 11

$$R = \frac{V}{I}$$
$$= \frac{240}{80}$$
$$= 3\text{A}$$ 1 mark

All switches on gives $3 \times 3 = 9\text{A}$. 1 mark

The fuse is rated to 8A so it most likely will melt and cut off the power. 1 mark

Question 12

At 19 V from the graph, $I = 0.4\text{A}$, so

$$P = VI$$
$$= 19 \times 0.4$$
$$= 7.6\text{ W}$$ 1 mark

Question 13

An ohmic device has $R = \frac{V}{I} = \text{constant}$ which would be seen on a $V - I$ graph as a straight line. 1 mark

The solar panel behaves as a non-ohmic device as R is not constant and the line is not straight. 1 mark

Question 14

Use $R = \frac{V}{I}$ and reading from the graph:

$$= \frac{20}{0.33}$$
$$= 60.6\ \Omega$$ 2 marks

Note: Accept range of 57 – 65 Ω

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

Detailed study 1 – Astronomy

Question 1 **B**

$$\text{Time} = \frac{\text{distance}}{\text{speed}}$$
$$= \frac{1.74 \times 10^{13}}{3 \times 10^{8}}$$
$$= 5.8 \times 10^{4}\text{ s}$$

$$\frac{5.8 \times 10^{4}\text{ s}}{3600} = 16\text{ hours}$$

Question 2 **C**

$$\frac{1.74 \times 10^{13}}{3.1 \times 10^{16}} = 0.56 \times 10^{-4}$$

Question 3 **A**

The zenith is the term used when an object in the sky is directly above the person.

Question 4 **D**

The south celestial pole appears to be at an altitude of 38°.

Question 5 **C**

Since Melbourne is in the southern hemisphere, more of the southern sky can be seen.

Question 6 **A**

On the equator, the person would see both the northern and southern skies equally.

Question 7 **B**

It takes the second star 12:30 – 02:00 = 10:30 hours to cross the same point in the sky.

Question 8 **D**

The Ptolemaic model had all celestial bodies orbiting Earth.

Question 9 **A**

The asteroid belt is located between Mars and Jupiter.

Question 10 **B**

The Earth's atmosphere absorbs large quantities of IR radiation.

Question 11 **A**

Since it is a mirror and not a lens, spherical aberration is what occurred.

Question 12 **C**

Stars appeared no different, even with the telescope, while planets appeared as discs.

Detailed study 2 – Astrophysics

Question 1 **B**

The Sun is an average main sequence star.

Question 2 **D**

All answers **A**, **B** and **C** provide plausible evidence for fusion as the source of the Sun's energy.

Question 3 **A**

The surface temperature of the Sun is about 5500°C.

Question 4 **C**

Gravitational forces are the main influence on the formation of large-scale structures in the universe.

Question 5 **C**

Parallax measurements can be used to find the distance to stars up to about 1600 light-years away. Beyond that, the method becomes too unreliable.

Question 6 **C**

The diameter of the Earth's orbit around the Sun is equal to 2 AU.

Question 7 **D**

Inverse square law can only be used to measure distance by comparing the brightness of stars of known distance to those of unknown distance.

Question 8 **B**

This is the only option that correctly shows a starting and ending stage of a star's life.

Question 9 **C**

It was the discovery of the Cosmic Background Radiation that spelt the end of the steady state theory.

Question 10 **B**

Doppler shift is used in cosmology to determine the relative motion of stars and galaxies.

Question 11 **C**

Hubble measured the speed of recession and related this to the distance of each Galaxy.

Question 12 **A**

The main conclusion from Hubble's work was that the universe is in a state of ongoing expansion.

Detailed study 3 – Energy from the nucleus

Question 1 **A**

The sun is powered by nuclear fusion reactions.

Question 2 **B**

Only heavy nuclei above $A = 56$ can release energy by fission.

Question 3 **B**

Isotope with $A = 56$ has the greatest binding energy per nucleon. This effectively means that its nucleons have the smallest mass on average.

Question 4 **D**

Binding energy can be defined as the energy required to break down the nucleus into its separate parts.

Question 5 **B**

Fission products are typically very rich in neutrons.

Question 6 **D**

Pu-239 is a fissionable nucleus.

Question 7 **C**

Slow-moving or thermal neutrons are more likely to be captured by U-235 nuclei and are therefore able to initiate fission.

Question 8 **B**

A sphere provides the least surface area for any given volume of nuclear fuel.

Question 9 **D**

All of the options **A** to **C** provide essential requirements for a nuclear chain reaction.

Question 10 **A**

Using $E = mc^2$, it can be shown that 3.43×10^{-28} kg is the correct mass defect.

Question 11 **C**

Chemical reactions are governed by the electromagnetic force whereas nuclear reactions are governed by the strong nuclear force which is much greater in magnitude.

Question 12 **A**

Using conservation of mass and charge, it can be seen that the missing particle X is a neutron: ${}^{1}_{0}n$.

Detailed study 4 - Investigations: Flight

Question 1 **D**

By heating the air, the density is decreased which creates buoyancy.

Question 2 **D**

In Figure 1, the weight and reaction force are opposite and equal, while in flight the lift force equals the weight.

Question 3 **A**

As the aerofoil moves through the air, it pushes down and the reaction force is the air pushing upwards.

Question 4 **C**

The rudder controls the yaw of the aircraft.

Question 5 **B**

As velocity increases, pressure decreases.

Question 6 **B**

Bernoulli's equation is based on the conservation of energy.

Question 7 **C**

$$P_1 - P_2 = \frac{1}{2}p(v_2^2 - v_1^2)$$

$$= \frac{1}{2}(1.29)(125^2 - 95^2)$$

$$= 4257 \text{ N m}^{-2}$$

$$= 4.3 \times 10^3 \text{ N m}^{-2}$$

Question 8 **D**

The wing is symmetrical so lift will be equal in either orientation.

Question 9 **B**

The winglets reduces vortices, which decreases drag.

Question 10 **A**

The extra range is 3% of 13 000 km, which equals 390 km.

Question 11 **D**

Use $P = Fv$.

Need to multiply by 4 (engines) and subtract the drag.

F(thrust) available $= 4 \times 250 - 24 = 976$ kN

Convert 900 km h^{-1} $= \frac{900}{3.6} = 250$ m s^{-1}

$$P = Fv = 976 \times 250 = 244\ 000 \text{ kW} = 244 \text{ MW}$$

Question 12 **A**

Convert 1300 km h^{-1} to 361.1 m s^{-1}. Then divide 361.1 by 330, which equals 1.09.

Detailed study 5 - Investigations: Sustainable energy sources

Question 1 **C**

Coal/oil/nuclear are energy sources that cannot be renewed.

Question 2 **A**

Coal and oil are both fossil fuels.

Question 3 **B**

Solar is most effective during daytime.

Question 4 **D**

Hydroelectric is the largest renewable energy source currently in use.

Question 5 **A**

A battery has chemical energy that gets converted to electrical energy.

Question 6 **C**

Uranium is a form of nuclear energy.

Question 7 **B**

From the graph, the compact fluorescent uses roughly 10 W.

The saving is $100 - \left(\frac{10 \text{ W}}{60 \text{ W}} \right) \times 100 = 100 - 17 = 83\%$.

Question 8 **B**

$\frac{66}{680} \times 100 \approx 10\%$

Question 9 **B**

Maximum power is approximately at the middle of the knee of the curve, roughly where $V = 0.45$ V and $I = 1.25$ A.

$P = VI$

$= 0.54$ W

Question 10 **A**

Cloudy means less light striking the panel so 200 W m^{-2} is most likely.

Question 11 **D**

By placing them facing north, more sunlight hits the panel throughout the day, giving a better power output average.

Question 12 **A**

The kinetic energy = potential energy = mgh

$= 120 \times 10 \times 45$

$= 54$ kW

Detailed study 6 - Medical physics

Question 1 **C**

Ultrasound is non-ionising and therefore the safest option for an unborn baby. CT scans allow for differentiation between brain tissue and tumour disease. In addition, a 3D positioning is possible using CT technology.

Question 2 **B**

X-rays form images by partial absorption of X-rays by different body cells/tissues.

Question 3 **B**

This is an ultrasound image.

Question 4 **C**

Gamma radiation is least ionising and therefore would cause least damage to the tissues through which it travels.

Question 5 **B**

Highly energetic X-rays can be fatal to cells. Especially tumour cells which are more sensitive to this type of radiation than normal brain cells. The energy needs to be absorbed for it to have an impact on the cell.

Question 6 **A**

It is the laser's high accuracy and the ability to focus on very small areas that makes this type of surgery possible.

Question 7 **D**

MRI relies on the alignment/disalignment of hydrogen atoms.

Question 8 **A**

Only PET scans rely on the injection of a radio isotope.

Question 9 **B**

It is the flexibility of optical fibres that make endoscopy possible.

Question 10 **D**

All the options **A** to **C** are requirements for a coherent bundle of optical fibres.

Question 11 B

Working inside a human body requires illumination.

Question 12 D

The barium would provide additional contrast for the X-rays.