ATAR course **Year 11 Physics**

Practice Exam 1 (Unit 1 & 2) **Answers**

Section one: **Short answer** (60 marks)

Question 1 (2 marks)

The shiny silver surface enables the space blanket to reflect heat back into the patient's body to keep them warm.

Question 2 (2 marks)

As the Space Shuttle re-entered Earth's atmosphere, the air friction increased and produced huge amounts of heat. The tiles were designed to re-radiate the heat back into the atmosphere and away from the pilots and crew, thus protecting them from heating up too much.

Question 3 (2 marks)

Double-glazed windows have two sheets of glass with a small air gap between them. The air trapped in the gap is an insulator, reducing heat conduction through the window. The fact that the air is trapped and cannot circulate reduces the effect of convection. (Note: Double glazing has minimal effect on radiation.)

Question 4 (4 marks)

The vacuum is an insulator and reduces heat loss by conduction and reduces convection in the gap. The silvering reflects heat back into the liquid reducing heat loss.

The stopper reduces evaporation from the surface and convection in the air space above the liquid. The double glass bottle is an insulator and reduces heat loss by conduction.

Question 5 (2 marks)

Isotopes are atoms that have the same number of protons but different numbers of neutrons in their nuclei. Both Ni-58 and Ni-63 have 28 protons in their nuclei. However, Ni-63 has 35 neutrons in its nucleus and Ni-58 only has 30. So they are both isotopes of nickel.

Question 6 (2 marks)

Radioisotopes are isotopes of an atom that are also radioactive. Ni-63 is radioactive because the extra 5 neutrons it has in its nucleus compared to Ni-58 makes its nucleus unstable. (To become more stable the Ni-63 atom will undergo radioactive decay to 'lose' its excess energy.)

Question 7 (4 marks)

Nuclear binding energy is the energy needed to totally separate the protons and neutrons in the nucleus.

Question 8 (1 mark)

The number of neutrons per fission needs to be greater than one.

Question 9 (2 marks)

Cadmium absorbs neutrons (without undergoing fission itself) thus preventing them from causing further nuclear fission.

Question 10 (2 marks)

X is 3 neutrons ($^{1}_{0}n$)

(In a nuclear equation the total number of nucleons and the number of protons on each side of the equation must be equal. The right-hand side of the equation requires three more neutrons to achieve balance.)

Question 11 (3 marks)

$E = \Delta mc^2$

$E = 2.12 \times 10^{-28} \times (3.0 \times 10^8)^2 = 1.91 \times 10^{-11}$ J

$E = 1.91 \times 10^{-11} \div (1.6 \times 10^{-19})$ eV $= 120 \times 10^6$ eV $= 120$ MeV

Question 12 (3 marks)

Effective resistance of circuit 1 = ½ R + R + R = 2.5 R

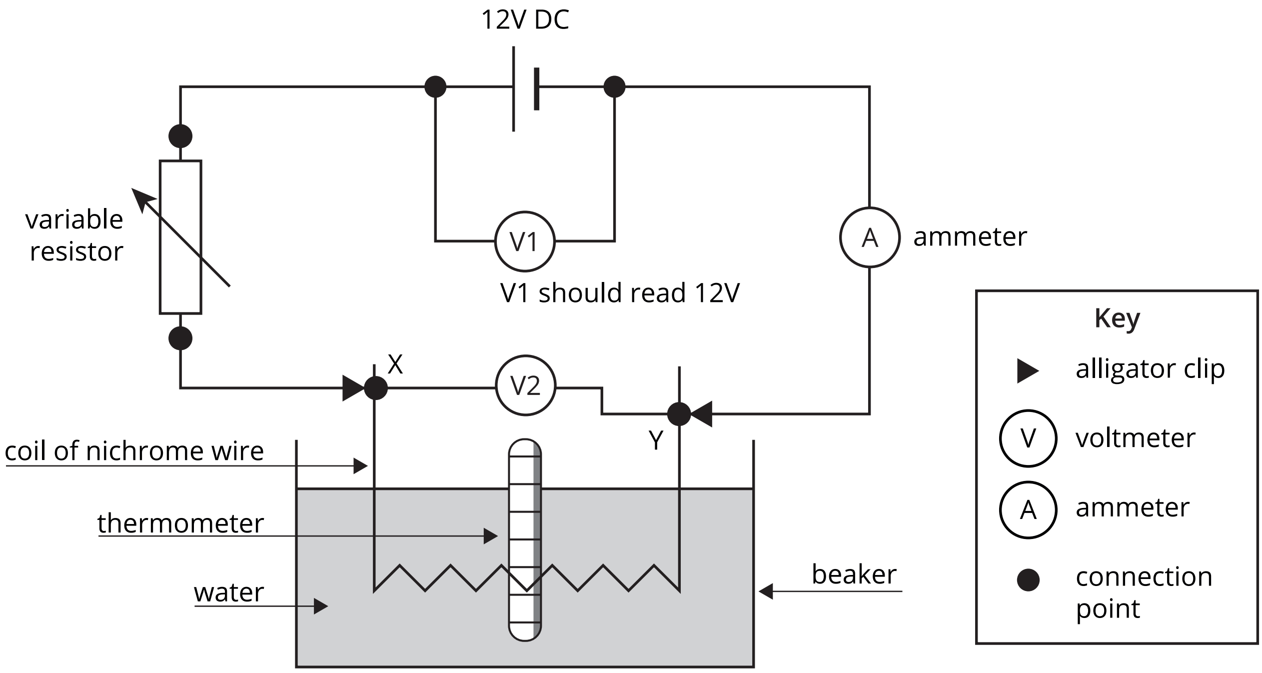
Effective resistance of circuit 2 = ½ R + ½ R = R

Therefore resistances of each circuit are different. The student did not achieve her aim.

(Students may substitute a value for R to work out the resistance of each circuit and compare them.)

Question 13 (6 marks)

Set up the following apparatus:



Vary the positions of connection points X and Y (on the uncut piece of nichrome) and choose a setting on the variable resistor so that the *product* of the readings of (V2) and (A) = 10 watts.

Energy input into the kettle = 10 W × time of continuous use in seconds

Energy output (accumulated by the water) = temperature change of water × 0.050 × 4180

% efficiency of the kettle = $\frac{\text{energy output} \times 100}{\text{energy input}}$

 ISBN 978 1 4860 2222 9

Question 14 (4 marks)

Ammeters are designed to have negligible resistance, whereas voltmeters are designed to have maximum possible resistance.

Ammeters need to have negligible resistance so that they do not alter the original value of the current in the circuit to be tested.

Voltmeters need to have high resistance so that they do not divert significant current away from the original circuit.

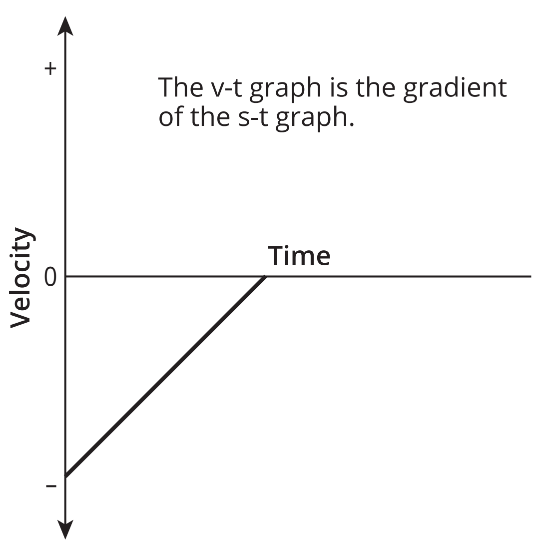
Question 15 (2 marks)

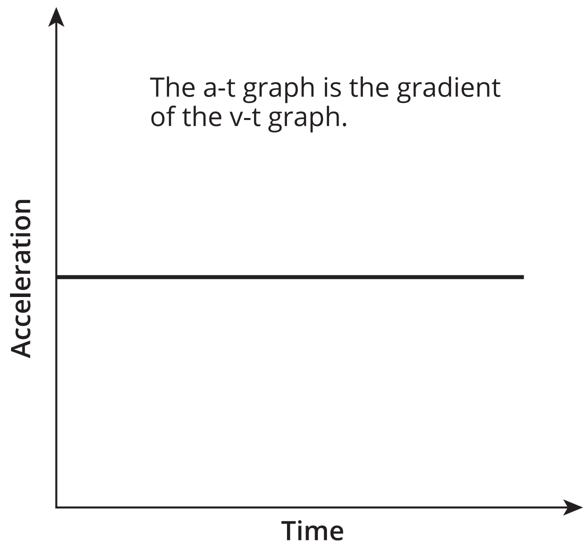
The force due to gravity on the gymnast is due to the force that the Earth exerts on him.

According to Newton's third law: $F_{A\ on\ B} = -F_{B\ on\ A}$. So the reaction force to the force due to gravity acting on the gymnast is the gravitational force that the gymnast exerts on the Earth.

(Remember that Newton's third law involves the forces acting on two bodies that are interacting with each other – in this case the gymnast and Earth. Equal and opposite reaction forces act on DIFFERENT objects. The tension force in the rings is acting on the gymnast so it is not the reaction force to the gymnast's weight.)

Question 16 (4 marks)





Question 17 (4 marks)

The Law of Conservation of Momentum will apply in this situation since it can be considered to be an 'isolated or closed' system since external forces such as friction between the road and vehicles is negligible. The total momentum of the system before impact must equal the total momentum of the vehicles after impact.

$p_{final} = (m_1 + m_2)\ v = (1000 + 2000) \times 9.43 = 2.83 \times 10^4$ kgms^{-1} at N 45° W

Since this is at 45°, the vector triangle of initial and final momentums will be an isosceles right angle triangle, hence the momentum of both vehicles before the collision was the same magnitude.

$p_{truck\ before} = p_{car\ before} = \sqrt{((2.83 \times 10^4)^2 \div 2)} = 2.0 \times 10^4$ kgms^{-1}

$2.0 \times 10^4 = 2000 \times u_{truck}$

$\therefore u_{truck} = 2.0 \times 10^4 \div 2000 = 10$ ms^{-1}

Obviously, the driver of Car A is wrong or possibly lying! The speed of the truck must have been significantly lower than 20 ms^{-1}!

 ISBN 978 1 4860 2222 9

Question 18 (3 marks)

$u = 0$, $v = 17.8$, $t = 9.4$, $a = ?$

$v = u + a\,t$

$17.8 = 0 + 9.4\,a \rightarrow a = 17.8 \div 9.4 = 1.89\ \text{ms}^{-2}$

$F_{net} = m \times a = 1000 \times 1.89 = 1890$ N or 1.89×10^3 N

Question 19 (3 marks)

$u = 14.5$, $v = 0$, $s = 350$, $a = ?$

$v^2 = u^2 + 2\,a\,s$

$0 = 14.5^2 + 700\,a$

$a = 14.5^2 \div -700 = -0.3$

$F_{net} = m \times a = 1600 \times 0.3 = 480$ N

Question 20 (1 mark)

Transverse or longitudinal.

Question 21 (2 marks)

Because light effectively slows down when it enters a medium with a higher refractive index (or speeds up in a medium with a lower refractive index). This change in speed causes the wave to bend or refract if the ray enters at an angle greater than 0 degrees to the normal.

Question 22 (2 marks)

Destructive, as the crest of one wave will cancel out the trough of the other (or vice versa).

Question 23 (3 marks)

$\propto I \alpha \frac{1}{d^2}$ or $I \times d^2$ = a constant, k

$k = 0.32 \times 5^2$

$k = 8.0$

$I_2\,(d_2)^2 = 8$

$(d_2)^2 = 8 \div 0.5 = 16$

$d_2 = 4.0$ m

 ISBN 978 1 4860 2222 9

Section two: **Problem solving** (90 marks)

Question 24 (12 marks)

a energy lost by cocktails = energy gained by melting ice

$m\ c\ \Delta T$ (cocktails) = $m\ L_f$ (ice)

$0.06 \times 2.7 \times 10^3 \times 26 = m$ (ice) $\times 3.34 \times 10^5$

m (ice) = $(4.212 \times 10^3) \div (3.34 \times 10^5) = 0.0126$ kg or 12.6 g

b energy lost by cocktails = energy gained by melting ice to water and heating water.

$m\ c\ \Delta T$ (cocktails) = $m\ L_f$ (ice) + $m\ c\ \Delta T$ (water)

$0.06 \times 2.7 \times 10^3 \times 16 = m$ (ice) $\times (3.34 \times 10^5 + 4.18 \times 10^3 \times 16)$

m (ice) = $(2.592 \times 10^3) \div (4.01 \times 10^5) = 0.0065$ kg or 6.5 g

c $E = P \times t = m\ c\ \Delta T$

$2000 \times t = 1.20 \times 4.18 \times 10^3 \times (100 - 26)$

$t = 371\ 184 \div 2000 = 186$ s

d Some of the heat energy goes into heating the kettle itself and some escapes into the air, so more heat energy is needed to heat the water, thus taking longer to boil.

e Explanation: Water vapour in the air next to the glass cools and liquefies producing the water droplets.

Description: As heat passes from the glass to the droplets they evaporate again thus cooling the glass itself, which helps keep the contents cool too.

Question 25 (5 marks)

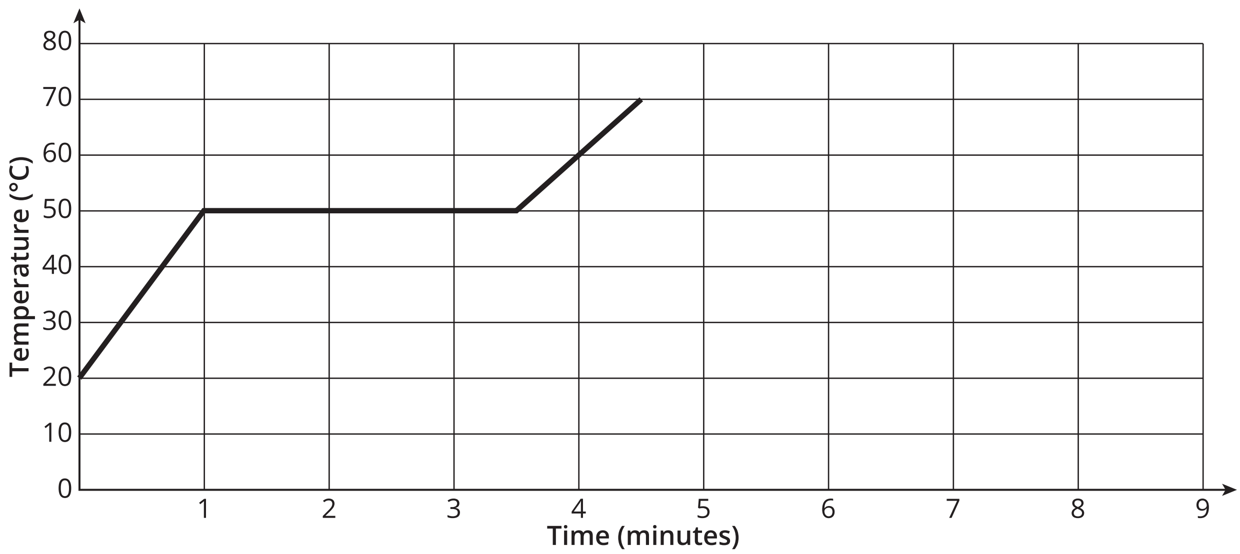
a 50°C (The melting temperature is shown by the plateau, i.e. flat section, on the graph.)

b $E = m \times L_f$

$50 \times 5 \times 60 = 0.25 \times L_f$

$L_f = 15\ 000 \div 0.25 = 6.0 \times 10^4$ Jkg^{-1}

c Double the heating rate takes half the time.



 ISBN 978 1 4860 2222 9

Question 26 (6 marks)

a $${}^{63}_{28}\text{Ni} \rightarrow {}^{63}_{29}\text{Cu} + {}^{0}_{-1}\beta + \text{energy}$$

(½ mark for each correct box)

b The β-particle was emitted from the atom's nucleus after one of the atom's neutrons turned into a proton and an electron. (The electron being the beta particle)

Question 27 (8 marks)

a $E = 7.39 \times 10^{6} \times 1.6 \times 10^{-19}$

$E = 1.18 \times 10^{-22}$ J

b $E = 100\,000 \times 34$ eV $= 3.4 \times 10^{6}$ eV OR 3.4 MeV

c distance = 7.39 MeV ÷ 3.4 MeV of energy lost per cm = 2.17 cm or 22 mm

d $N = N_0(\frac{1}{2})^{n}$

n = number of half-lives that have passed = $(4.13 \times 10^{-3}) \div (1.78 \times 10^{-3}) = 2.32$

$N = 100 \times (\frac{1}{2})^{2.32} = 20$ %

Question 28 (7 marks)

a $q = I \times t = 1.9 \times 10^{-3} \times 1.00 \times 10^{-4} = 1.90 \times 10^{-7}$ C

b number of electrons = $\frac{q}{1.6 \times 10^{-19}}$

number of electrons = $1.9 \times 10^{-7} \div (1.6 \times 10^{-19}) = 1.19 \times 10^{12}$ electrons

c $E = V \times I \times t = 350 \times 1.9 \times 10^{-3} \times (1.00 \times 10^{-4} \times 10 \times 2.00) = 1.33 \times 10^{-3}$ J

Question 29 (10 marks)

a Because X and Y are connected in series the current flowing through them will be 50 mA. Using this information and reading directly from the graph gives:

$V_X = 3.0$ V and $V_Y = 5.0$ V

emf $= V_X + V_Y = 3.0 + 5.0 = 8.0$ V

b $R = \frac{V}{I} = 3 \div 0.050 = 600\ \Omega$

c Conductor X is an example of a non-ohmic conductor.

The reason why conductor X is non-ohmic is because for different values of V and I its ratio of I to V (i.e. its resistance) is not constant.

d Conductors X and Y are now connected in parallel. This means that the potential difference across them will be the same and that the circuit current will be equal to the sum of the currents flowing through them. Using this information and reading directly from the graph gives:

$I_X = 60$ mA and $I_Y = 60$ mA

$I_{total} = I_X + I_Y = 60 + 60 = 120$ mA

e $P = V \times I = 6.0 \times 0.060 = 0.36$ W

Question 30 (17 marks)

a Calculate the effective resistance for the parallel part of the circuit first.

$\frac{1}{R_?} = \frac{1}{200} + \frac{1}{600}$

$\frac{1}{R_?} = \frac{4}{600} = \frac{1}{150}$

$R_{parallel} = 150\ \Omega$

$R_{total} = 150 + 650 = 800\ \Omega$

b Firstly, calculate the total current flowing in the circuit:

$I = \frac{V}{R} = \frac{6.0}{800} = 7.5 \times 10^{-3}$ A or 7.5 mA

$V_{parallel\ pair} = I \times R = 7.5 \times 10^{-3} \times 150 = 1.125$ V

$I_{600} = V \div R = 1.125 \div 600 = 1.88 \times 10^{-3}$ A or 1.88 mA

Question 31 (11 marks)

a $v = 54 \div 3.6 = 15$ ms^{-1}

b $u = 15$, $t = 1.2$, $a = 0$, $s = ?$

$s = u\,t + ½\,a\,t^2$

$s = 15 \times 1.2 + 0 = 18$ m

c $u = 15$, $v = 0$, $t = 4.4$, $a = ?$

$v = u + a\,t$

$0 = 15 + 4.4\,a$

$a = 15 \div 4.4 = 3.41$ ms^{-2}

d Stopping distance (SD) = Reaction distance (RD) + Braking distance (BD)

RD = 18 m (from part b)

BD: $u = 15$, $v = 0$, $t = 4.4$, $a = 3.41$, $s = ?$

$s = ½\,(u + v) \times t$

$s = ½\,(15 + 0) \times 4.4 = 33$ m

$\therefore$ stopping distance = 18 + 33 = 51 m

e Work done = change in energy = ΔKE

$\Delta KE = ½\,m\,(\Delta v)^2 = 0.5 \times 1600 \times 15^2 = 180\,000$ J or 1.8×10^5 J

OR

Work done = Force × distance

$F = m \times a$

$F = 1600 \times 3.41 = 5455$ N

$W = 5455 \times 33 = 180\,000$ J or 1.80×10^5 J

 ISBN 978 1 4860 2222 9

Question 32 (13 marks)

a Acceleration = gradient of the v-t graph at t = 60 s

gradient = $\frac{\text{rise}}{\text{run}} = \frac{0-15}{65-50}$ = −1.0 ms^{-2}

$\therefore$ acceleration = 1.0 ms^{-2}

b F_{net} = 0 (constant velocity means a = 0 and $F_{net} = m\,a$)

c Acceleration = gradient between t = 0 and t = 10 s

gradient = $\frac{\text{rise}}{\text{run}} = \frac{0-15}{65-50}$ = 1.5 ms^{-2}

$F_{net} = m \times a$ = 32 000 × 1.5 = 48 000 N

$F_{net} = F_{driving} - F_{resistive}$

48 000 = 61 300 − $F_{resistive}$

$\therefore F_{resistive}$ = 61 300 – 48 000 = 13 300 N or 13.3 kN

d The bus's average speed will be equal to distance it covers over time. The distance covered is equal to the area under the graph.

Area = (½ × 10 × 15) + (40 × 15) + (½ × 15 × 15) + (25 × 0) + (½ × 10 × 10) + (25 × 10) + (½ × 15 × 10) + (10 × 0)

= 75 + 600 + 112.5 + 0 + 50 + 250 + 75 + 0 = 1162.5 m

Average velocity = 1162.5 ÷ 150 = 7.75 ms^{-1}

Question 33 (4 marks)

a $c = f\lambda \rightarrow f = \frac{c}{\lambda}$

f = 3.00 × 10^{8} ÷ (405 × 10^{-9}) = 7.41 × 10^{14} Hz

b $T = \frac{1}{f}$ = 1 ÷ (7.41 × 10^{14}) = 1.35 × 10^{-15} s

Question 34 (7 marks)

a 0.40 m (amplitude is measured from the centre to a peak or a trough)

b there are 2 complete waves in the diagram

c 2.00 m (measured from an initial position on the wave to the next identical position)

d 2 Hz (2 complete waves have been produced in one second)

e $v = s / t$ = 4 / 1 = 4 ms^{-1} (wave has travelled 2 m in one second)
$v = f\lambda$ = 2 × 2 = 4 ms^{-1}

f 0.5 s (from $T = 1 / f$)

 ISBN 978 1 4860 2222 9

Section 3 Comprehension (30 marks)

Question 35 (8 marks)

a Ionising ability

The chosen radioisotope needs to be strongly ionising. Of the radiation types emitted by the parent radioisotopes, α-particles are the most strongly ionising.

Based on this criterion, Pu-238 and Cf-250 are the most appropriate choice of radioisotope for the RTG. Their daughter isotopes are also emitters of α-particles.

b Shielding

To protect *Voyager 2*'s instruments the emitted radiation has to be prevented from reaching the RTG. Gamma rays are the most penetrating type of radiation and are difficult to shield against. This means that Ag-108 and Cs-137 are unsuitable because the gamma rays they emit, and in Cs-137's case those emitted by its daughter isotope, will damage *Voyager 2*'s instruments over time.

c Working lifetime (Note: students have already ruled out Ag-108 and Cs-137 from part (**b**) above and narrowed it down to Pu-238 and Cf-250 from part (**a**) so not all data needs to be calculated as shown below.

Ag-108	**Ni-63**	**Cs-137**	**Pu-238**	**Cf-250**
$t_{1/2}$ = 418 years	$t_{1/2}$ = 100 years	$t_{1/2}$ = 30.2 years	$t_{1/2}$ = 88 years	$t_{1/2}$ = 13.1 years
t = 35 years	t = 35 years	t = 35 years	t = 35 years	t = 35 years
$A = A_0\,(½)^n$	$A = A_0\,(½)^n$	$A = A_0\,(½)^n$	$A = A_0\,(½)^n$	$A = A_0\,(½)^n$
$A = 100\,(½)^{35/418}$	$A = 100\,(½)^{35/100}$	$A = 100\,(½)^{35/30.2}$	$A = 100\,(½)^{35/88}$	$A = 100\,(½)^{35/13.1}$
A = 94% > 40%	A = 78% > 40%	A = 45% > 40%	A = 76% > 40%	A = 17% < 40%
∴ Ag-108 has a suitable working life	∴ Ni-63 has a suitable working life	∴ Cs-137 has a suitable working life	∴ Pu-238 has a suitable working life	∴ Cf-250 does not have a suitable working life

d The only radioisotope that satisfies all three criteria is Pu-238.

Question 36 (11 marks)

a

$$^{10}_{5}\mathrm{B} + {}^{\boxed{1}}_{\boxed{0}}\mathrm{n} \rightarrow {}^{\boxed{11}}_{\boxed{5}}\mathrm{B} \rightarrow {}^{\boxed{7}}_{\boxed{3}}\mathrm{Li} + {}^{4}_{2}\alpha + {}^{0}_{0}\boxed{}$$

(½ mark for each correct box)

b absorbed dose = $\frac{\text{energy} \in \text{joules}}{\text{mass} \in \text{kg}}$

absorbed dose = $\frac{0.50}{0.070}$ = 7.1 Gy

c dose equivalent = absorbed dose × quality factor

QF of alpha particles = 20

Dose equivalent = 7.1 × 20 = 143 Sv

d The energy of the emitted α-particles and the Li-7 daughter isotope is enough to ionise other atoms in the tumour, or to break the bonds between atoms. If this were to occur a sufficient number of times within a cancer cell it would die.

 ISBN 978 1 4860 2222 9

Question 37 (11 marks)

a $E = P \times t$

For globe 1: $E = 100 \times 1 \times 60 \times 60 = 3.6 \times 10^5$ J (per hour)

For globe 2: $E = 20 \times 1 \times 60 \times 60 = 7.2 \times 10^4$ J (per hour)

b For globe 1, the total energy used during its lifetime would be:

$E_{globe\ 1} = 3.6 \times 10^5 \times 1000 = 3.6 \times 10^8$ J

Cost to run = \$0.208 per kWh and 1 kWh = $1000 \times 60 \times 60 = 3.6 \times 10^6$ J

To match globe 2's lifetime of 10 000 hours, 10 of globe 1 would be needed.

Cost of globe 1 = 10 × purchase price = 10 × \$1.20 = \$12.00

Cost to operate globe 1 for 10 000 hours = $10 \times 3.6 \times 10^8 \div (3.6 \times 10^6) \times \$0.208 = \$208$

Total cost of globe 1 = \$12 + \$208 = \$220

For globe 2, the total energy used during its lifetime would be:

$E_{globe\ 2} = 7.2 \times 10^4 \times 10\,000 = 7.2 \times 10^8$ J

Cost to operate globe 2 for 10 000 hours = $7.2 \times 10^8 \div (3.6 \times 10^6) \times \$0.208 = \$41.60$

Total cost of globe 2 = \$5.60 + \$41.60 = \$47.20

∴ Globe 2 is much more economical to run.

End of answers

