Question 1 **(4 marks)**

Any two of:

- Matter is made of particles in constant motion (E_K)
- Collisions of particles are elastic (E_K)
- Mutual attraction of particles (E_P)

Question 2 **(5 marks)**

a) Electron & Positron

b) positron has a positive charge; electron has a negative charge

c)

Mass relative to a proton	~1/2000 – 1/1830
Speed	~0.9 c (accept 'high')
Ionising Power	Weak

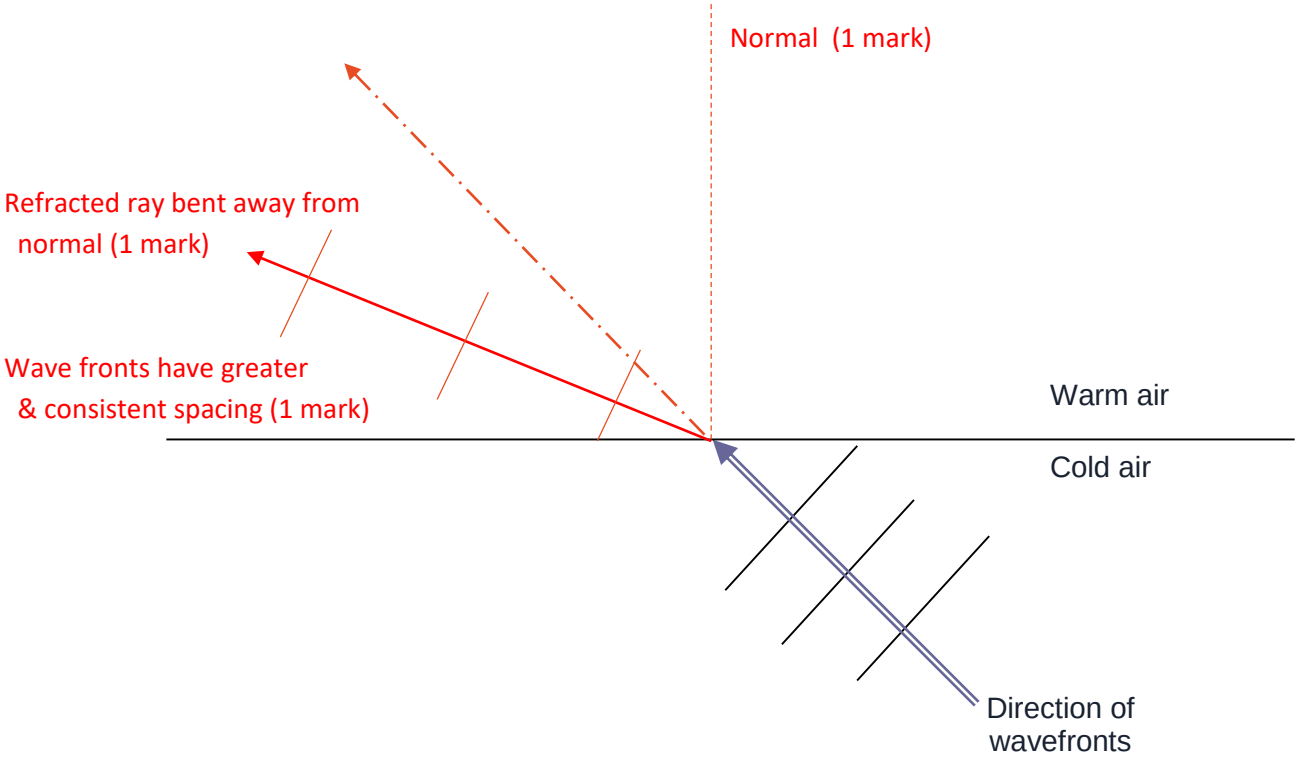
Question 3 **(5 marks)**

a) If there is an imbalance of current flowing into and out of the house of more than a predetermined amount (1 mark)
the RCD breaks the circuit in a very short time (1 mark)

b) Yes (1 mark)

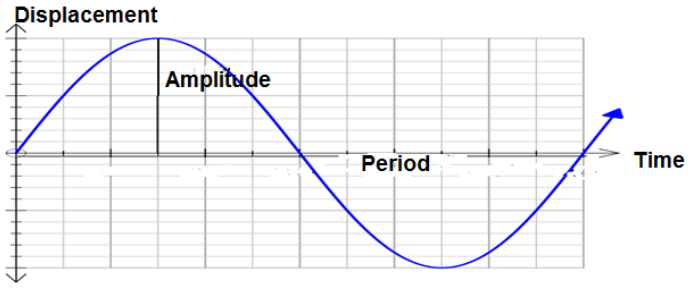
If a person touches both wires (active & neutral) and becomes part of circuit (1 mark) and no current flows to Earth (1 mark)

Question 4 **(3 marks)**

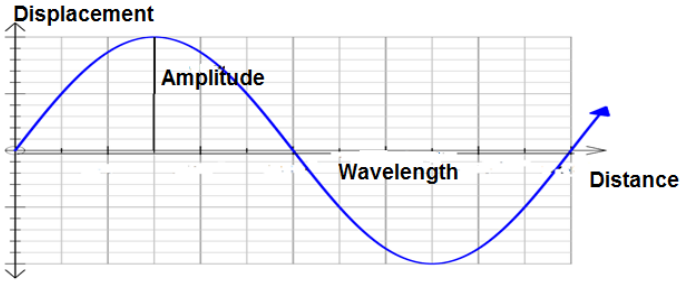


Question 5 **(3 marks)**

i) Displacement/time



ii) Displacement/distance

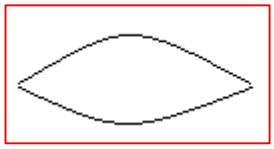


(1 mark each for showing wavelength, period, and amplitude)

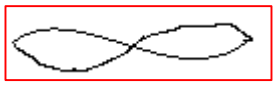
Question 6 **(6 marks)**

a)

1st **Sketch** (1 mark) **Wavelength = _____**1.30 m (1 mark)



2nd **Sketch** (1 mark) **Wavelength = _____**0.650 m (1 mark)



b) $f = \frac{v}{\lambda}$

1st $f = \frac{400}{1.3} = 308\ Hz$ 1 mark

2nd f = 2 x 308 = 615 Hz 1 mark

Question 7 **(3 marks)**

Water evaporates (1 mark), water particles with highest E_K leave (1 mark). Average E_K lower hence lower temperature (1 mark)

Accept any other answer that uses conduction, convection & radiation to address the question

Question 8 **(4 marks)**

a) Energy gained by water = Energy transferred out of nickel (conservation of energy)

$Q_{water} = mc\Delta T$

$= 1.59 \text{ kg} \times 4180 \text{ J kg}^{-1} \text{ K}^{-1} \times (32.3 - 21.0) \text{ K}$ (1 mark)

$= 7.51 \times 10^4 \text{ J}$

Energy transferred out of nickel = 7.51×10^4 J (1 mark)

b) $Q_{nickel} = mc\Delta T$

$c = Q/m\Delta T$

$= 75102.06/(0.337 \times (534-32.3)$

$= 444 \text{ J kg}^{-1} \text{ K}^{-1}$ (1 mark for answer, 1 mark for correct units)

Question 9 **(3 marks)**

a) A = counts per second = 7.776×10^3 counts/$(24 \text{ h} \times 3600 \text{ s h}^{-1}) = 9.00 \times 10^{-2}$ Bq

b) $N = N_o(½)^n$

$\ln(N/N_o) = \ln(0.5)n$

$n = \ln(0.09/0.36)/\ln(0.5)$

= 2 half lives (1 mark)

Age of thigh bone = $2 \times 5730 = 1.15 \times 10^4$ years old

Question 10 **(2 marks)**

Temperature is a measure of the average kinetic energy of the particles of a substance. Within any given population, individual particles may have a much greater or lower kinetic energy than the average. (1 mark)

Molecules in the glass will be in constant motion resulting in elastic collisions which transfer sufficient kinetic energy to some molecules allowing them to escape in the gaseous state, thus the water will evaporate over time. (1 mark)

Question 11 **(4 marks)**

a) Gold has free electrons due to its lattice structure and current flows (1 mark) whereas rubber has no free electrons (1 mark).

b) Gold has large numbers of delocalised electrons that transfer energy quickly (1 mark) compared to electrons fixed (rubber) (1 mark)

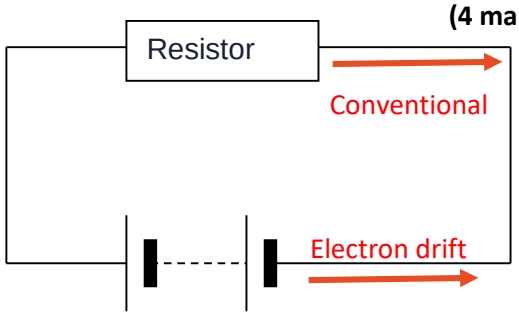
Question 12 **(4 marks)**

$q = It$

$I = q/t$

$= (6.02 \times 10^{23} \text{ electrons} \times 1.60 \times 10^{-19} \text{ C electron}^{-1})/70.0 \text{ s}$

$= 1.38 \times 10^3$ A



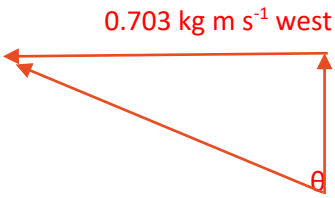
Question 13 **(5 marks)**

$P_{initial} = mv = 1.90 \times 10^{-3}$ kg x 3.70×10^{2} m s^{-1}

= 0.703 kg m s^{-1} east

$P_{final} = mv = 1.90 \times 10^{-3}$ kg x 1.80×10^{2} m s^{-1}

= 0.342 kg m s^{-1} north (1 mark)



north (1 mark)

$\Delta P = P_{final} - P_{initial}$

= 0.342 kg m s^{-1} north - 0.703 kg m s^{-1} east

= 0.342 kg m s^{-1} north + 0.703 kg m s^{-1} west

= $\sqrt{(0.342^2 + 0.703^2)}$

= $\sqrt{(0.611}$

= 0.781 kg m s^{-1} (1 mark)

$\theta = \tan^{-1}(0.703/0.342)$

= 64.1° (1 mark)

The change in momentum was 0.781 kg m s^{-1} N 64.1° W (1 mark)

Question 14 **(3 marks)**

V = W/q

W = Vq

= 1.23×10^{3} V x 1.60×10^{-19} C (1 mark)

= 1.97×10^{-16} J (1 mark)

= 1.97×10^{-16} J/1.60×10^{-19} J eV^{-1}

= 1.23×10^{3} eV (1 mark)

Section Two: Problem-solving **50% (90 Marks)**

This section has **eight (8)** questions. Answer **all** questions. Write your answers in the spaces provided.

Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

- Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
- Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question that you are continuing to answer at the top of the page.

Suggested working time: 90 minutes.

Question 15 **(6 marks)**

a) 1.2 MeV/nucleon (1 mark) (2 significant figures for estimate)

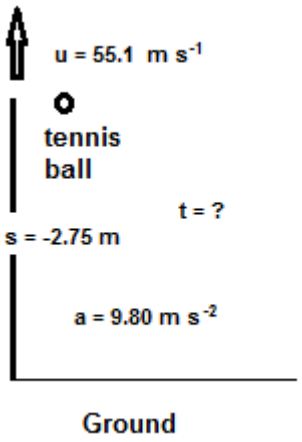
b) Left of Fe- 56 (1 mark)
As particles combine MeV/Nucleon increases (1 mark)

c) 5 MeV/nucleon (1 mark)
1 u = 931 MeV (1 mark)
Mass difference = 5/931 u = 5.37×10^{-3} u (1 mark)

Question 16 **(13 marks)**

a) up is +ve

$s = ut + \frac{1}{2}at^2$
$-2.75 = 55.1\ t - 4.90\ t^2$
$t = 11.3$ s



b) t = 5.10 s
v = u + at
= 55.1 + (-9.80 x 5.10) (1 mark)
= 5.12 m s^{-1} up (1 mark)

See next page

Question 16 (cont.)

c) Highest point v = 0

$v^2 = u^2 + 2as$

$0 = 55.1^2 - 19.6\ s$ (1 mark)

$s = 1.55 \times 10^2$ m (1 mark)

Total distance = $(2 \times 1.55 \times 10^2) + (2.75)$

$= 3.13 \times 10^2$ m (1 mark)

d) $E_M = E_K + E_P$ (1 mark)

$= 0.5\ mv^2 + mgh$

$= 0.5 \times 0.0573 \times 55.1^2 + 0.0573 \times 9.8 \times 2.75$ (1 mark)

$= 8.85 \times 10^1$ J (1 mark)

e) $F = (mv - mu)/t$

$= 0.0573\ (55.1 - 0)/0.312$ (1 mark)

$= 1.01 \times 10^1$ N (1 mark)

See next page

Question 17 **(13 marks)**

a) Artificial transmutation refers to the inducing of fission reactions in fissile atoms by bombarding them with neutrons (as opposed to the spontaneous radioactive decay which radioactive isotopes undergo naturally)

b) A fissile atom will produce 2-3 neutrons when it undergoes a neutron-induced nuclear fission. These neutrons can then induce further fission events in other atoms, with this iterative process producing a chain reaction.

(1 mark)

Diagram (1 mark)

Each fission event releases energy which is used in the generation of power (1 mark)

c)

1 mark each (up to 3 marks) for:

- Fuel for nuclear fusion is readily available and relatively cheap
- There is much less radioactive waste produced by nuclear fusion
- More energy is released per nucleon by nuclear fusion
- Any other valid response

d) AD = E/m
= 27.0 J/93.0 kg
= 0.290 Gy (1 mark for correct calculation; 1 mark for correct units)

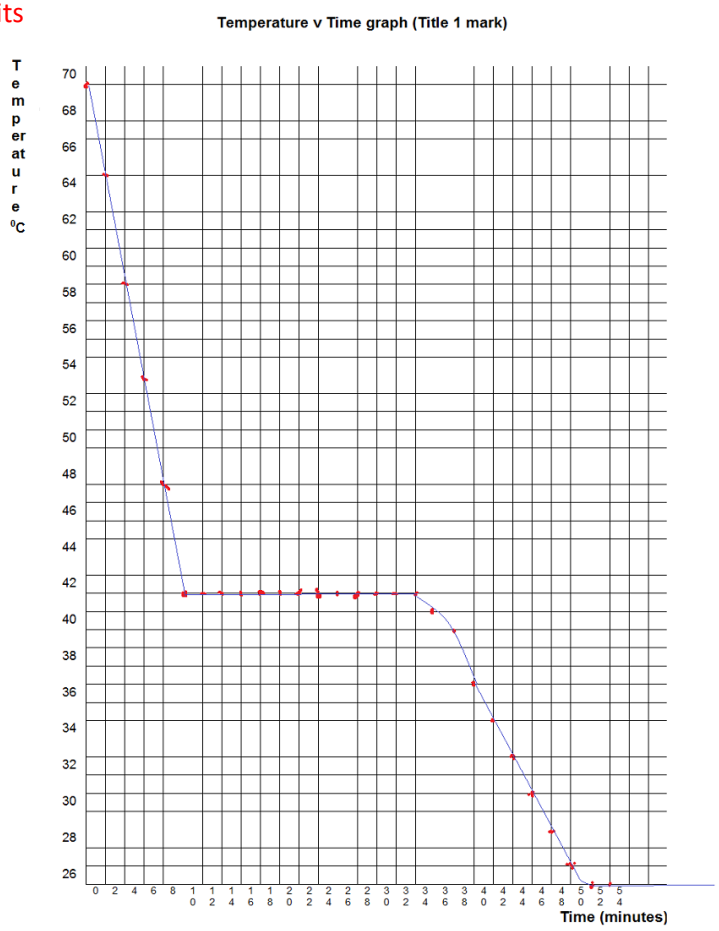
e) DE = AD * QF
= 0.290 G x 3
= 8.71×10^{-1} Sv (1 mark for correct calculation; 1 mark for correct units)

f) This dose is close to 1 Sv, so the worker may experience some nausea and diarrhoea in the short term and they may have an enhanced risk of cancers later in life. (1 mark)
The worker should avoid further exposure to the contaminated fuel by requesting to be assigned to other duties. (1 mark)

See next page

Question 18 **(14 marks)**

a) 1 mark for each labelled axis with units
1 for accuracy
1 for line of best fit



b) 50 minute is 2330 J vapour 10 minutes = 2330 x 10/50 = 466 J

$c = Q/m\,\Delta T$

$= 466/(1.3 \times 10^{-3} \times 28)$

$= 1.28 \times 10^{4}$ J kg^{-1} K^{-1} (1 mark)

liquid 10 minutes 466 J

$c = Q/m\,\Delta T$

$= 466/(1.3 \times 10^{-3} \times 10)$

$= 3.58 \times 10^{4}$ J kg^{-1} K^{-1} (1 mark)

$c_{liquid}/c_{vapour} = 3.58/1.28 = 2.80$

OR c_{liquid} 3 x c_{vapour} (1 mark)

c) Gas & liquid (1 mark)

d) As temp difference decreases (1 mark) heat transfer is smaller (1 mark)

See next page

Question 18 (cont.)

e) $Q = 2330 \text{ J}/50 \text{ min} \times 24 \text{ min}$
$= 1118.4 \text{ J}$ (1 mark)

$Q = mL_v$
$L_v = Q/m$
$= 1118.4/1.30 \times 10^{-3}$
$= 8.60 \times 10^5 \text{ J kg}^{-1}$ (1 mark)

f) Temp did not decrease no change in E_K (1 mark)

Particles got closer together decrease in E_P (1 mark)

Question 19 **(16 marks)**

a) $P = 3.00 \text{ W}; V = 12.0 \text{ V}$
$I = P/V = 3.00/12.0$ (1 mark)
$I = 0.250 \text{ A}$ (1 mark)

(i) Current in Globe 2 (2 marks)

$P = 12.0 \text{ W}; V = 36.0 \text{ V}$
$I = P/V = 12.0/36.0$ (1 mark)
$I = 0.333 \text{ A}$ (1 mark)

(ii) Resistance of R2 (3 marks)

$V = 36.0 - 12.0 = 24.0$ (1 mark)
$I = 0.250 \text{ A}$
$R = V/I = 24.0/0.250$ (1 mark)
$R = 96.0 \Omega$ (1 mark)

(iii) Resistance of R1 (3 marks)

$V = 6.00 \text{ V}$ (1 mark)
$I = (0.333 + 0.250)$
$= 0.583 \text{ A}$ (1 mark)
$R = V/I$
$= 6.00/0.583$
$= 10.3 \Omega$ (1 mark)

(v) The total resistance of the circuit (3 marks)

$V = 36 \text{ V}$ (1 mark)
$I = (0.333 + 0.250)$
$= 0.583 \text{ A}$ (1 mark)
$R = V/I$
$= 36/0.583$
$= 61.7 \Omega$ (1 mark)

See next page

b)

(i) Ammeter? (2 marks)

0.583 A (2 marks)

(ii) Voltmeter? (1 mark)

36.0 V (1 mark)

Question 20 **(9 marks)**

(a) How far did the hiker walk? (1 mark)

50 km (1 mark)

(b) Calculate the velocity (km h^{-1}) in the following segments:

(i) AB (1 mark)

20 km/4 h = 5 km h^{-1} N

(ii) EF (1 mark)

0.0 km h^{-1} (stationary)

(iii) AG (1 mark)

0.0 km h^{-1} (stationary)

(iv) DE (1 mark)

5 km/5 h = 1 km h^{-1} S

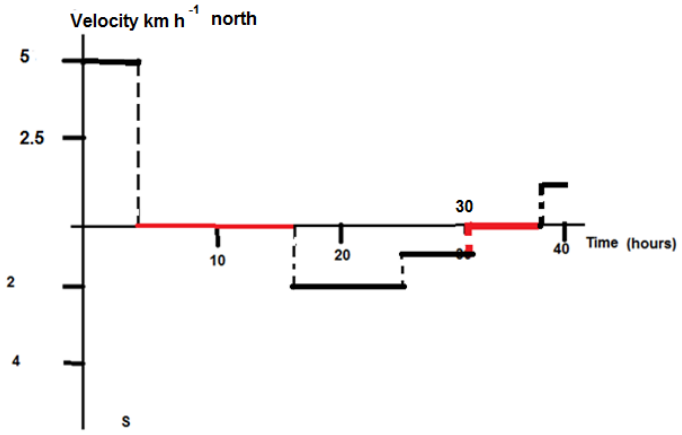
(c) Draw a graph of velocity versus time. (3 marks)

Axes & Units (1 mark)
All lines horizontal/vertical (no slopes) (1 mark)
Changes at correct times (1 mark)

See next page

(d) For how long was the walker stationary? (1 mark)

17 +/- 2 hours



Question 21 **(10 marks)**

a) 333 Hz is the natural (fundamental) frequency of the air column in the pipe (1 mark)
Since the forcing frequency matches the natural frequency, the sound is amplified (1 mark)

b) Sketch should show antinodes at each end with a node in the centre

c) Candle should be placed in the centre of the pipe (1 mark)
Since this is a displacement node, the air particles will not be displaced by the sound wave energy and the candle's flame will be steady. (1 mark)

d) The pipe is 52.5 cm long.

(i) What is the wavelength of the sound? (2 marks)

$L = \frac{1}{2}\lambda$

$\lambda = 2L$ (1 mark)

$= 2 \times 0.525$ m $= 1.05$ m (1 mark)

(ii) What is the speed of sound in the tube? (1 mark)

$v = \lambda f$

$= 1.05 \times 333 = 350$ m s^{-1}

e) I) Sketch should show antinodes at both ends and in the centre, with 2 nodes evenly spaced

(ii) What is the frequency of this overtone? (1 mark)

$\lambda = L = 0.525$ m (1 mark)

$v = \lambda f$

$f = v/\lambda$

$= 350/0.525 = 666$ Hz (1 mark)

OR $f_2 = 2 \times f_1 = 2 \times 333$ Hz $= 666$ Hz

See next page

Question 22 **(9 marks)**

a) Incandescent relies on heating a metal filament (1 mark)
Fluorescent relies on exciting electrons and then allowing them to return emitting emr that is absorbed by fluorescent powder which emits light (1 mark)
Incandescent gets much hotter (waste) (1 mark)

b) 80% x 18 = 14.4 W (1 mark)
14.4/100 = 14.4% efficient (1 mark)

(c)

(i) compact fluorescent globe (3 marks)

Power lost as waste heat = 20% x 18.0 W = 3.60 W (1 mark)
W = P x t
W = 3.60 W x 3600 s (1 mark)
W = 1.30 x 10^4 J (1 mark)

(ii) incandescent globe (1 mark)

W = 85.6% x 100 W x 3600 s
= 3.08 x 10^5 J (1 mark)

End of Section Two

See next page

Section Three: Comprehension **20% (36 Marks)**

Question 23 **(20 marks)**

a) Only 0.1% energy loss as alpha (α) passes out of nanoparticle (1 mark)
Retains Bismuth (1 mark)
Retains recoil (1 mark)

b)

$^{225}_{89}Ac \rightarrow {}^{4}_{2}He + {}^{221}_{87}Fr$ 221-Francium

$^{221}_{87}Fr \rightarrow {}^{4}_{2}He + {}^{217}_{85}At$ 217-Astatine

$^{217}_{85}At \rightarrow {}^{4}_{2}He + {}^{213}_{83}Bi$ 213-Bismuth

(1 mark for each correct equation, 1 mark for correct name of each daughter particle)

c) (i)

Directly attack DNA (1 mark)
Bigger punch 5 Mev compared with a few hundred keV (1 mark)

(ii)
Large mass OR large charge (1 mark)

d)
$E_K = ½mv^2$
E_K = 5 MeV
= 5 x 10^6 x 1.6 x 10^{-19} J
= 8.00 x 10^{-13} (1 mark)

$v = \sqrt{(E_K/0.5 \times m)}$
$= \sqrt{(8 \times 10^{-13}/0.5 \times 6.64424 \times 10^{-27})}$ (1 mark)
= 1.55 x 10^7 m s^{-1} (1 mark)

e)
(i) mm is 10^3 bigger than micron (1 mark)
V increase by 10^9 (1 mark)

(ii) Fast moving beta particles collide with the atom causing an e^- to be removed (1 mark)

(iii) DNA not able to carry out normal reactions (1 mark)
Not able to replicate hence dies (1 mark)

See next page

Question 24 **(16 marks)**

a) E_K of car (1 mark) is converted to noise, heat and deforming (1 mark)

b) Newton's Second Law commonly written as F = ma (1 mark)
Can be rewritten as F = (mv – mu)/t (1 mark)
t increases (1 mark)
F decreases, hence less force on occupants (1 mark)

c) Better at keeping occupant in place (1 mark)
Prevents body/head for going forward and hitting something (1 mark)

d) m = 3.00 kg; v = 0; t = 0.100 s
u = 72.0 km h^{-1} = 72.0/3.6 = 20.0 m s^{-1} (1 mark)

F = (mv- mu)/t
= (3 x 0 – 3 x 20)/0.100 (1 mark)
= 6.00 x 10^2 N (1 mark)

e) Whiplash is generally caused by crashes where the person is in the vehicle hit from behind (1 mark)
According to Newton's First Law the unrestrained head continues forward and then body "jerks" it back (1 mark)
The head rest reduces how far back the head can snap back (1 mark)

f) Inflate quickly to prevent head hitting solid object (1 mark)
Deflate quickly to prevent suffocation (1 mark)

END OF EXAMINATION

See next page