**Q1.** A paintball gun is used to fire a small ball of paint, called a paintball, at a target.

The figure below shows someone just about to fire a paintball gun.

The paintball is inside the gun.

(a) What is the momentum of the paintball before the gun is fired?

.....

Give a reason for your answer.

.....

.....

**(2)**

(b) The gun fires the paintball forwards at a velocity of 90 m / s.

The paintball has a mass of 0.0030 kg.

Calculate the momentum of the paintball just after the gun is fired.

Use the correct equation from the Physics Equations Sheet.

.....

.....

.....

Momentum = ..... kg m / s

**(2)**

(c) The momentum of the gun and paintball is conserved.

Use the correct answer from the box to complete the sentence.

| | | |
|---|---|---|
| **equal to** | **greater than** | **less than** |

The total momentum of the gun and paintball just after the gun is fired

will be ..... the total momentum of the gun and paintball

before the gun is fired.

**(1)**

**(Total 5 marks)**

**Q2.** (a) Nuclear fission is used in nuclear power stations to generate electricity. Nuclear fusion happens naturally in stars.

(i) Explain briefly the difference between *nuclear fission* and *nuclear fusion*.

.....

.....

.....

.....

.....

**(2)**

(ii) What is released during both nuclear fission and nuclear fusion?

.....

**(1)**

(b) Plutonium-239 is used as a fuel in some nuclear reactors.

(i) Name another substance used as a fuel in some nuclear reactors.

.....

**(1)**

(ii) There are many isotopes of plutonium.

What do the nuclei of different plutonium isotopes have in common?

.....

**(1)**
**(Total 5 marks)**

**Q3.** (a) There are many isotopes of the element molybdenum (Mo).

What do the nuclei of different molybdenum isotopes have in common?

.....

**(1)**

(b) The isotope molybdenum-99 is produced inside some nuclear power stations from the nuclear fission of uranium-235.

(i) What happens during the process of nuclear fission?

.....

.....

**(1)**

(ii) Inside which part of a nuclear power station would molybdenum be produced?

.....

**(1)**

(c) When the nucleus of a molybdenum-99 atom decays, it emits radiation and changes into a nucleus of technetium-99.

$$^{99}_{42}Mo \longrightarrow {}^{99}_{43}Tc + \text{Radiation}$$

What type of radiation is emitted by molybdenum-99?

.....

Give a reason for your answer.

.....

.....

**(2)**

(d) Technetium-99 has a short half-life and emits gamma radiation.

What is meant by the term ‘half-life’?

.....

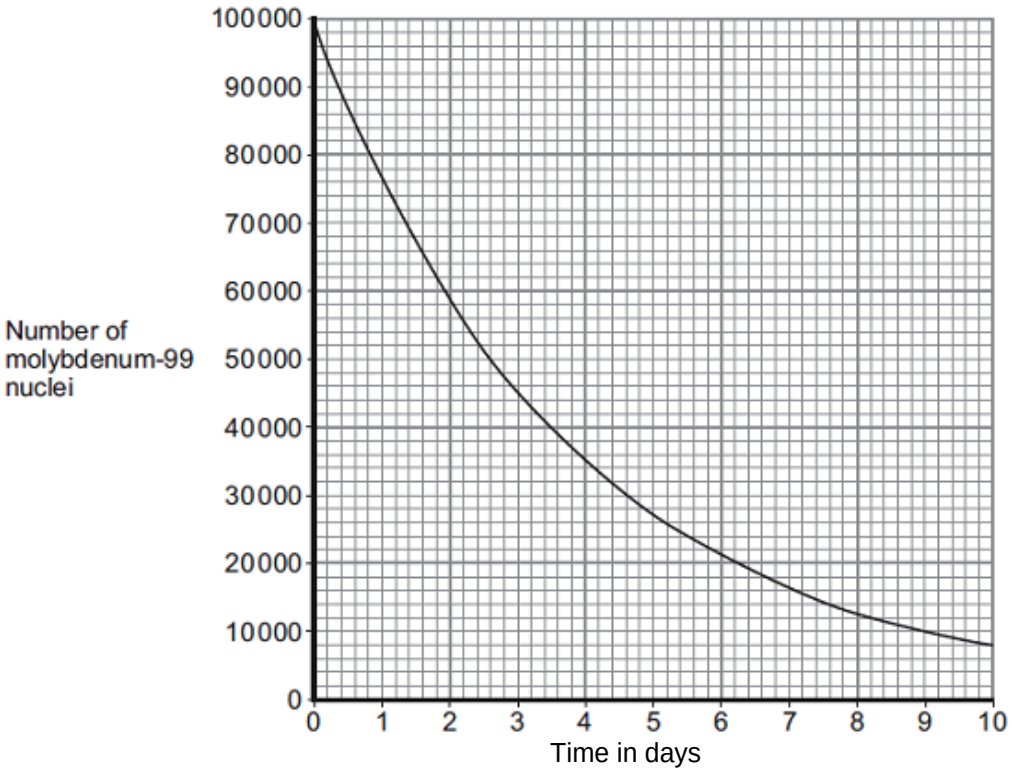
.....

.....

**(1)**

(e) Technetium-99 is used by doctors as a medical tracer. In hospitals it is produced inside a technetium generator by the decay of molybdenum-99 nuclei.

(i) The figure below shows how the number of nuclei in a sample of molybdenum-99 changes with time as the nuclei decay.




A technetium generator will continue to produce sufficient technetium-99 until 80% of the original molybdenum nuclei have decayed.

After how many days will a source of molybdenum-99 inside a technetium-99 generator need replacing?

Show clearly your calculation and how you use the graph to obtain your answer.

.....

.....

.....

Number of days = .....

**(2)**

(ii) Medical tracers are injected into a patient's body; this involves some risk to the patient's health.

Explain the risk to the patient of using a radioactive substance as a medical tracer.

.....

.....

.....

.....

**(2)**

(iii) Even though there may be a risk, doctors frequently use radioactive substances for medical diagnosis and treatments.

Suggest why.

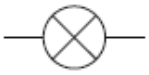
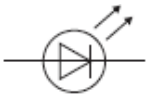
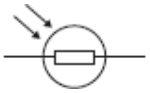
.....

.....

**(1)**

**(Total 11 marks)**

**Q4.** (a) Draw **one** line from each circuit symbol to its correct name.

| **Circuit symbol** | **Name** |
|---|---|
|  | Diode |
|  | Light-dependent resistor (LDR) |
|  | Lamp |
| | Light-emitting diode (LED) |

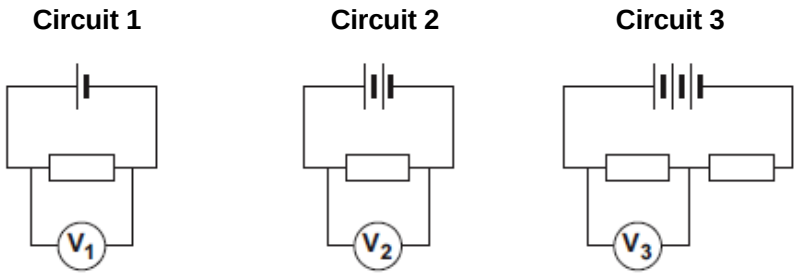
**(3)**

(b) **Figure 1** shows three circuits.

The resistors in the circuits are identical.

Each of the cells has a potential difference of 1.5 volts.

**Figure 1**




(i) Use the correct answer from the box to complete the sentence.

| | | |
|---|---|---|
| **half** | **twice** | **the same as** |

The resistance of **circuit 1** is ..... the resistance of **circuit 3**.

**(1)**

(ii) Calculate the reading on voltmeter $\mathbf{V_2}$.

.....

Voltmeter reading $\mathbf{V_2}$ = ..... V

**(1)**

(iii) Which voltmeter, $\mathbf{V_1}$, $\mathbf{V_2}$ or $\mathbf{V_3}$, will give the lowest reading?

Draw a ring around the correct answer.

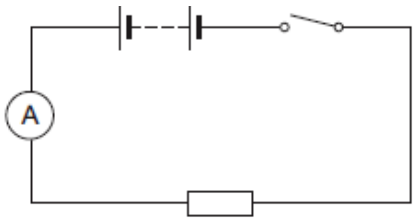
$\mathbf{V_1}$ $\mathbf{V_2}$ $\mathbf{V_3}$

**(1)**

(c) A student wanted to find out how the number of resistors affects the current in a series circuit.

**Figure 2** shows the circuit used by the student.

**Figure 2**



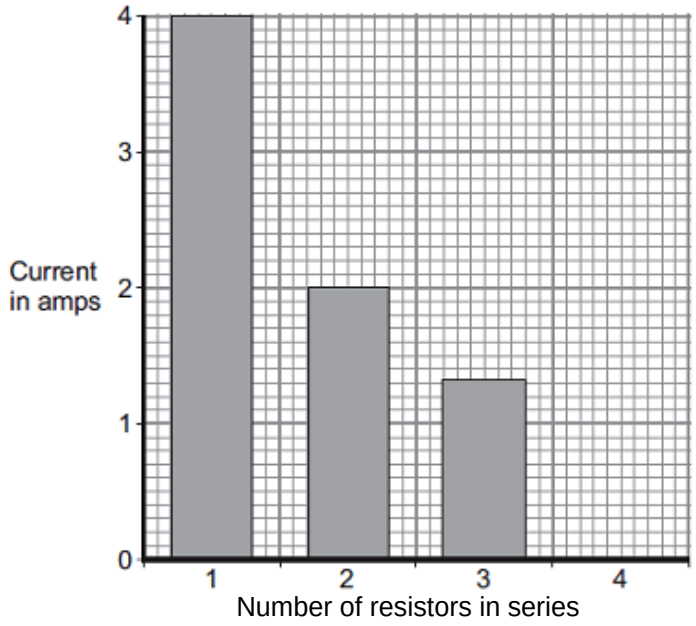

The student started with one resistor and then added more identical resistors to the circuit.

Each time a resistor was added, the student closed the switch and took the ammeter reading.

The student used a total of 4 resistors.

**Figure 3** shows three of the results obtained by the student.

**Figure 3**




(i) To get valid results, the student kept one variable the same throughout the experiment.

Which variable did the student keep the same?

.....

**(1)**

(ii) The bar chart in **Figure 3** is not complete. The result using 4 resistors is not shown.

Complete the bar chart to show the current in the circuit when 4 resistors were used.

**(2)**

(iii) What conclusion should the student make from the bar chart?

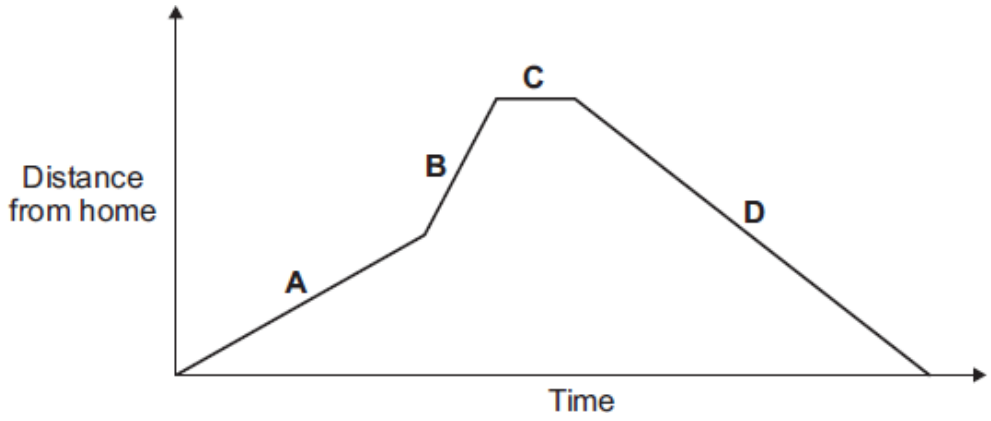
.....

.....

**(1)**
**(Total 10 marks)**

**Q5.** (a) A person takes their dog for a walk.

The graph shows how the distance from their home changes with time.




Which part of the graph, **A**, **B**, **C** or **D**, shows them walking the fastest?

Write your answer in the box. ☐

Give the reason for your answer.

.....

.....

**(2)**

(b) During the walk, both the speed and the velocity of the person and the dog change.

How is *velocity* different from *speed*?

.....

.....

**(1)**
**(Total 3 marks)**

**Q6.** (a) The stopping distance of a vehicle is made up of two parts, the thinking distance and the braking distance.

(i) What is meant by *thinking distance*?

.....

.....

**(1)**

(ii) State **two** factors that affect thinking distance.

1 .....

.....

2 .....

.....

**(2)**

(b) A car is travelling at a speed of 20 m/s when the driver applies the brakes. The car decelerates at a constant rate and stops.

(i) The mass of the car and driver is 1600 kg.

Calculate the kinetic energy of the car and driver before the brakes are applied.

Use the correct equation from the Physics Equations Sheet.

.....

.....

.....

Kinetic energy = ..... J

**(2)**

(ii) How much work is done by the braking force to stop the car and driver?

Work done = ..... J

**(1)**

(iii) The braking force used to stop the car and driver was 8000 N.

Calculate the braking distance of the car.

Use the correct equation from the Physics Equations Sheet.

.....

.....

.....

.....

Braking distance = ..... m

**(2)**

(iv) The braking distance of a car depends on the speed of the car and the braking force applied.

State **one** other factor that affects braking distance.

.....

.....

**(1)**

(v) Applying the brakes of the car causes the temperature of the brakes to increase.

Explain why.

.....

.....

.....

.....

**(2)**

(c) Hybrid cars have an electric engine and a petrol engine. This type of car is often fitted with a regenerative braking system. A regenerative braking system not only slows a car down but at the same time causes a generator to charge the car's battery.

State and explain the benefit of a hybrid car being fitted with a regenerative braking system.

.....

.....

.....

.....

.....

.....

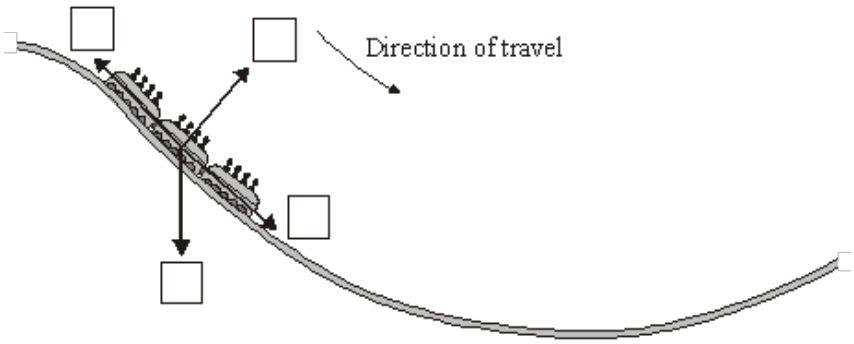
**(3)**

**(Total 14 marks)**

**Q7.** The diagram shows the passenger train on part of a rollercoaster ride.

(a) Which arrow shows the direction of the resultant force acting on the passenger train?

Put a tick (✓) in the box next to your choice.




**(1)**

(b) At the bottom of the slope, the passengers in the train all have the same speed but they each have a different kinetic energy.

Why is the kinetic energy of each passenger different?

.....

.....

**(1)**

(c) For part of the ride, the maximum gravitational field strength acting on the passengers seems 3 times bigger than normal.

Normal gravitational field strength = 10 N/kg

(i) Calculate the maximum gravitational field strength that seems to act on the passengers during the ride.

.....

.....

Maximum gravitational field strength = ..... N/kg

**(1)**

(ii) One of the passengers has a mass of 80 kg.

Use the equation in the box to calculate the maximum weight this passenger seems to have during the ride.

| weight = mass × gravitational field strength |
|---|

Show clearly how you work out your answer.

.....

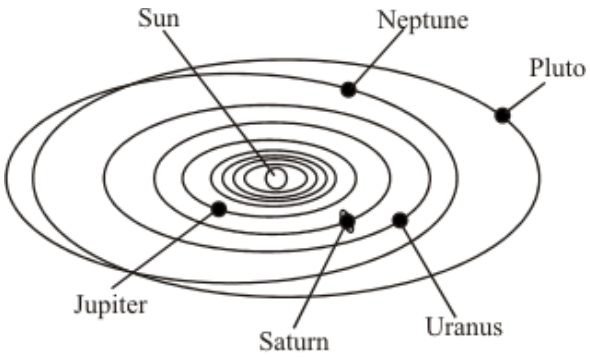
.....

Maximum weight = ..... N

**(2)**

**(Total 5 marks)**

**Q8.** The Sun at the centre of our solar system is a star.




(a) The Sun contains nuclei of the heaviest elements. Atoms of these heaviest elements are also present in the planets of the solar system. What does this suggest about the material from which the solar system is formed?

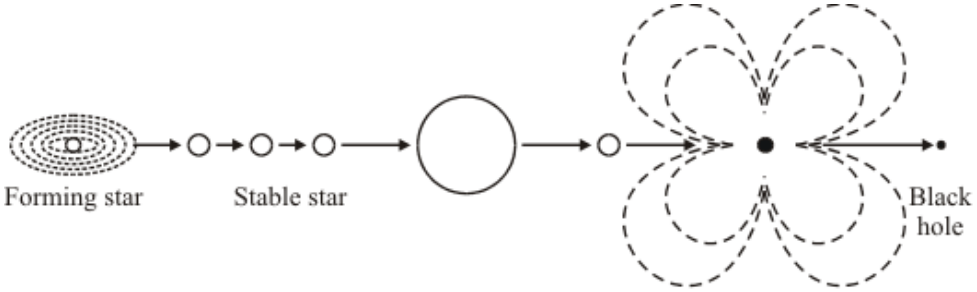
.....

.....

.....

**(1)**

(b) Stars form from gas (mostly hydrogen) and dust.




Describe, in as much detail as you can, what forces allow a stable star to exist and how the star may eventually form a black hole.

*To gain full marks in this question you should write your ideas in good English. Put them into a sensible order and use the correct scientific words.*

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

**(6)**
**(Total 7 marks)**

**M1.** (a) Zero / 0

*Accept none*
*Nothing is insufficent*

**1**

velocity / speed = 0

*accept it is not moving*
*paintball has not been fired is insufficient*

**1**

(b) 0.27

*allow **1** mark for correct substitution, ie p = 0.003(0) × 90 provided no subsequent step*

**2**

(c) equal to

**1**

**[5]**

**M2.** (a) (i) (nuclear) fission is the splitting of a (large atomic) nucleus

*do **not** accept particle/atom for nucleus*

**1**

(nuclear) fusion is the joining of (two atomic) nuclei (to form a larger one)

*do not accept particles/atoms for nuclei*

**1**

(ii) energy

*accept heat/radiation/nuclear energy*
*accept gamma (radiation)*
*do not accept neutrons/neutrinos*

**1**

(b) (i) uranium (–235)

*accept U (–235)*
*ignore any numbers given with uranium*
*accept thorium*
*accept MOX (mixed oxide)*
*do **not** accept hydrogen*

**1**

(ii) (same) number of protons

*accept (same) atomic number*
*accept (same) positive charge*
*ignore reference to number of electrons*

**1**

**[5]**

**M3.** (a) (same) number of protons

*same atomic number is insufficient*

**1**

(b) (i) nuclei split

*do **not** accept atom for nuclei / nucleus*

**1**

(ii) (nuclear) reactor

**1**

(c) beta

**1**

any **one** from:

- atomic / proton number increases (by 1)

  *accept atomic / proton number changes by 1*
- number of neutrons decreases / changes by 1
- mass number does not change

  *(total) number of protons and neutrons does not change*
- a neutron becomes a proton

**1**

(d) (average) time taken for number of nuclei to halve
**or**
(average) time taken for count-rate / activity to halve

**1**

(e) (i) 6.2 (days)

*Accept 6.2 to 6.3 inclusive*
*allow **1** mark for correctly calculating number remaining as 20 000*
***or***
*allow **1** mark for number of*
*80 000 plus correct use of the graph (gives an answer of 0.8 days)*

**2**

(ii) radiation causes ionisation

*allow radiation can be ionising*

**1**

that may then harm / kill healthy cells

*accept specific examples of harm, eg alter DNA / cause cancer*

**1**

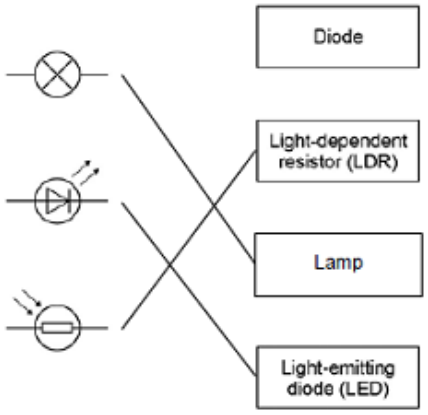
(iii) benefit (of diagnosis / treatment) greater than risk (of radiation)

*accept may be the only procedure available*

**1**

**[11]**

**M4.** (a)




*allow **1** mark for each correct line if more than one line is drawn from any symbol then all of those lines are wrong*

**3**

(b) (i) half

**1**

(ii) 3(V)

**1**

(iii) $V_1$

**1**

(c) (i) potential difference / voltage of the power supply

*accept the power supply*
*accept the voltage / volts*
*accept number of cells / batteries*
*accept (same) cells / batteries*
*do not accept same ammeter / switch / wires*

**1**

(ii) bar drawn – height 1.(00)A

*ignore width of bar*

*allow **1** mark for bar shorter than 3rd bar*

**2**

(iii) as the number of resistors increases the current decreases

**1**

**[10]**

**M5.** (a) **B**

*reason only scores if B is chosen*

**1**

gradient / slope is the steepest / steeper

*answers must be comparative*
*accept steepest line*
*ignore greatest speed*

**1**

(b) (velocity includes) direction

*'it' refers to velocity*

1

**[3]**

**M6.** (a) (i) distance vehicle travels during driver's reaction time

*accept distance vehicle travels while driver reacts*

1

(ii) any **two** from:

- tiredness
- (drinking) alcohol
- (taking) drugs
- speed
- age

*accept as an alternative factor distractions, eg using a mobile phone*

2

(b) (i) 320 000

*allow **1** mark for correct substitution, ie* $\frac{1}{2} \times 1600 \times 20^2$ *provided no subsequent step shown*

2

(ii) 320000 **or** their (b)(i)

1

(iii) 40

**or**

$\frac{\text{their (b)(ii)}}{8000}$ correctly calculated

*allow **1** mark for statement work done = KE lost*

***or***

*allow **1** mark for correct substitution, ie*
*8000 × distance = 320 000 **or** their (b)(ii)*

2

(iv) any **one** from:

- icy / wet roads
  *accept weather conditions*
- (worn) tyres
- road surface
- mass (of car and passengers)
  *accept number of passengers*
- (efficiency / condition of the) brakes

**1**

(v) (work done by) friction
(between brakes and wheel)
*do **not** accept friction between road and tyres / wheels*

**1**

(causes) decrease in KE and increase in thermal energy
*accept heat for thermal energy accept*
*KE transferred to thermal energy*

**1**

(c) the battery needs recharging less often
*accept car for battery*

**1**

**or**

increases the range of the car
*accept less demand for other fuels **or** lower emissions **or** lower fuel costs*
*environmentally friendly is insufficient*

as the efficiency of the car is increased
*accept it is energy efficient*

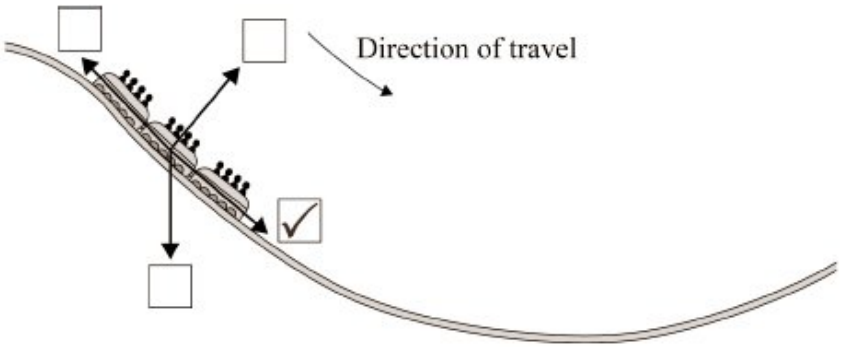
**1**

the decrease in (kinetic) energy / work done charges the battery (up)
*accept because not all work done / (kinetic) energy is wasted*

**1**

**[14]**

**M7.** (a) correct box ticked




**1**

(b) each passenger has a different mass

*accept weight for mass*

*ignore other irrelevant factors about the person e.g. mass and height*

*do not accept a list with incorrect factors e.g. mass and position*

*accept passengers started with different (gravitational) potential energy*

**1**

(c) (i) 30

*ignore added units*

**1**

(ii) 2400

*accept their (c)(i) × 80 correctly calculated for both marks*

*allow 1 mark for correct substitution of their (c)(i) and 80*

*an answer of 800 gains 1 mark only if answer to (c)(i) is not 10*

**2**

**[5]**

**M8.** (a) materials produced when earlier stars exploded

*accept the Sun is a second generation star*

*accept formed from nebulae*

**1**

(b) **Quality of written communication:**

1 mark for correct sequencing balanced forces → expansion → contraction / explosion

**1**

any **five** from

gravity pulling matter together

*accept idea that a star is very massive so its force of gravity is very strong*

high temperatures that create expansion forces

*nuclear fusion releases energy that causes the very high temperatures*

these forces balance

star expands greatly

since expansion is greater than gravity

*accept fuel runs out*

forms a red giant

*give no further marks if red giant → white dwarf, red dwarf etc*

collapses inwards and explodes outwards

called a supernova

neutron star may form

leaves a small, dense object (a black hole)

*accept nothing can escape from it*

**5**

**[7]**