

Mark schemes

Q1.

- (a) 0.08 (s) 1
- (b) the current goes higher than normal value
allow the current goes (too) high
- or**
the current goes higher than 1.5 A 1
- (c) $P = 1.5 \times 24$ 1
- $P = 36$ (W) 1
- an answer of 36 (W) scores 2 marks*
- (d) LED lamps waste a smaller proportion of the input energy than filament lamps 1

[5]

Q2.

- (a) potential difference
allow p.d.
allow voltage 1
- temperature 1
- in this order only*
- (b) the current increases (when the potential difference increases) 1
- (which) causes the temperature of the filament to increase 1
- (so) the resistance increases
*do **not** accept resistance increases and then levels off* 1
- (c) a higher proportion / percentage of the (total) power / energy input is usefully transferred
wastes less energy is insufficient
- or**
higher (useful) power / energy output for the same (total) power / energy input 1
- (d) potential difference increases 1

current decreases

1

(e) 1000 (Ω)

reason only scores if $R = 1000$ (Ω)

1

potential difference is shared in proportion to the resistance

allow a justification using a correct calculation

1

(f) $12 = I \times 7000$

1

$$I = \frac{12}{7000}$$

1

$$I = 1.71 \times 10^{-3} \text{ (A)}$$

an answer that rounds to 1.7×10^{-3} (A) scores 3 marks

1

$$I = 1.7 \times 10^{-3} \text{ (A)}$$

this answer only

or

$$I = 0.0017 \text{ (A)}$$

an answer of 2.4×10^{-3} (A) scores 2 marks

if no other marks scored allow 1 mark for calculation of total resistance (7000 Ω)

1

an answer of 1.7×10^{-3} (A) scores 4 marks

[14]

Q3.

(a) risk of electric shock (if someone touched the case)

allow risk of electrocution (if someone touched the case)

1

(b) $2530 = I \times 230$

this mark may be awarded if P is incorrectly / not converted

1

$$I = \frac{2530}{230}$$

this mark may be awarded if P is incorrectly / not converted

1

$$I = 11 \text{ (A)}$$

this answer only

an answer of 0.011 (A) scores 2 marks

1

an answer of 11 (A) scores 3 marks

(c) $E = 2530 \times 14$

this mark may be awarded if P is incorrectly / not converted

1

$E = 35\,420 \text{ (J)}$

this answer only

1

$35\,420 = m \times 4200 \times 70$

allow their calculated $E = m \times 4200 \times 70$

1

$$m = \frac{35\,420}{4200 \times 70}$$

allow $m = \frac{\text{their calculated } E}{4200 \times 70}$

1

$m = 0.12 \text{ (kg)}$

allow an answer that is consistent with their calculated value of E

1

[9]

Q4.

(a) current

1

(b) $4.2 = 3.5 \times 10^{-3} \times R$

1

$R = 4.2 / 3.5 \times 10^{-3}$

1

$R = 1200 \text{ (}\Omega\text{)}$

an answer of 1200 (Ω) scores 3 marks

an answer of 1.2 scores 2 marks

1

(c) conversion from minutes to seconds (300 s)

1

$Q = 0.0035 \times (5 \times 60)$

1

$Q = 1.05 \text{ C}$

an answer of 1.05 (C) scores 3 marks

an answer of 17.5 scores 1 mark

an answer of 1050 or 0.0175 scores 2 marks

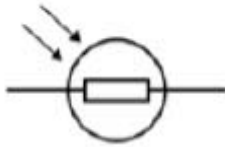
1

(d) (potential difference) increases

1

(because thermistor) resistance increases
2nd mark dependent on scoring 1st mark

1



(e)

1

[10]

Q5.

(a) any **two** from:

- calculate a mean
- reduces the effect of random errors
reduces human error is insufficient
- identify / remove anomalies
allow to assess the repeatability of the data

2

(b) random error

allow a parallax error
human error is insufficient

1

(because) eye position would not be the same each time (relative to the liquid)
allow systematic error only if it is clear that the student always viewed liquid level from above meniscus (or below)

1

(c) (a temperature increase would) increase the pressure in the tube
(even if the volume was constant)

1

(because a higher temperature would mean) higher (average) kinetic energy
of molecules / particles

allow higher (average) speed for higher (average) kinetic energy

1

(d) $1.6 \times 10^5 \times 9.0 (= 1.44 \times 10^6)$

1

$$1.44 \times 10^6 = 1.8 \times 10^5 \times V$$

allow for 2 marks

$$V = \frac{1.6 \times 10^5 \times 9.0}{1.8 \times 10^5}$$

1

or

$$V = \frac{1.44 \times 10^6}{1.8 \times 10^5}$$

$$V = 8.0 \text{ (cm}^3\text{)}$$

an answer of 8.0 (cm³) scores 3 marks

- (e) work is done on the air (in the tyre)

so the temperature (of the air) increases

allow the (average) kinetic energy of the particles increases

1

1

1

[11]

Q6.

- (a) 1 (cm³)

1

- (b) pressure is inversely proportional to volume

1

data to prove inversely proportional relationship

eg $8 \times 200 = 1600$

and $10 \times 160 = 1600$

if no other marks score allow for 1 mark: as volume decreases pressure increases

2

- (c) (as the gas is compressed) the volume of gas decreases

1

(so there are) more frequent collisions of gas particles with container walls

1

(and) each particle collision with the wall causes a force

1

(so there is a) greater force on walls

1

[8]

Q7.

- (a) smoke absorbs / stops alpha radiation

allow alpha particles for alpha radiation

alpha radiation does not reach the detector is insufficient

1

- (b) alpha radiation is not very penetrating

allow alpha particles for alpha radiation

or

alpha radiation does not penetrate skin

allow alpha radiation does not travel very far (in air)

1

- (c) beta and gamma radiation will penetrate smoke

| | | |
|-----|---|-----|
| | <i>allow beta and gamma radiation will not be stopped by smoke</i> | 1 |
| | no change (in the count rate) would be detected <i>allow the change detected (in the count rate) would be too small</i> | 1 |
| (d) | (a long half-life means) the count rate is (approximately) constant <i>allow activity of source is (approximately) constant</i> | |
| | or a short half-life means the count rate decreases quickly | 1 |
| | until 1.3 half-lives the count rate is above 80 per second <i>allow after 1.3 half-lives the count rate is below 80 per second</i> | |
| | or until 1.3 half-lives the count rate is above the threshold for the smoke alarm to be activated | |
| | or after 1.3 half-lives the smoke alarm will be activated all the time <i>so don't have to replace source or smoke detector is insufficient</i> | 1 |
| (e) | Level 2: Relevant points (reasons / causes) are identified, given in detail and logically linked to form a clear account. | 3-4 |
| | Level 1: Relevant points (reasons / causes) are identified, and there are attempts at logically linking. The resulting account is not fully clear. | 1-2 |
| | No relevant content | 0 |
| | Indicative content | |
| | <ul style="list-style-type: none"> • short half-life or half-life of a few hours • (short half-life means) less damage to cells / tissues / organs / body • low ionising power • (low ionising power means) less damage to cells / tissues / organs / body • highly penetrating • (highly penetrating means) it can be detected outside the body • emits gamma radiation | |

[10]

Q8.

- (a) any **three** from:
- no carbon dioxide emitted (to produce electricity)
no greenhouse gases is insufficient

- doesn't cause global warming
allow climate change or greenhouse effect for global warming
- nuclear power doesn't cause earthquakes
- more energy released per kg of fuel (compared to shale gas)

3

- (b) uranium
or
plutonium

ignore any numbers given

1

- (c) a neutron is absorbed by a (large) nucleus
a description in terms of only atoms negates first two marking points

1

the nucleus splits into two (smaller) nuclei

1

releasing energy (and gamma rays)

1

and (two / three) neutrons

1

[8]

Q9.

- (a) most alpha particles pass straight through the atom

1

which shows that the atom is mostly empty space

1

very few alpha particles are deflected through a large angle

1

which shows the atom contains a nucleus where the mass / charge of the atom is concentrated

1

- (b) electron may absorb electromagnetic radiation
full credit may be scored for a description of an electron emitting electromagnetic radiation

1

(and) move further from the nucleus

1

to a higher energy level

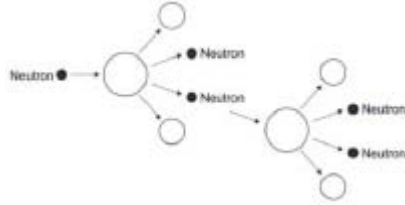
1

[7]

Q10.

- (a) Nucleus splitting into two fragments and releasing two or three neutrons 1
- (at least one) fission neutron shown to be absorbed by additional large nucleus and causing fission 1
- two or three additional neutrons released from fission reaction 1

This diagram would gain all 3 marks:



- (b) lowering the control rods increases the number of neutrons absorbed
accept converse description 1
- (so) energy released decreases 1
- allow changing the position of the control rods affects the number of neutrons absorbed for 1 mark*
- (c) rate of increase between 240 and 276 (MW / min) 2
- allow 1 mark for attempt to calculate gradient of line at 10 minutes*

[7]

Q11.

- (a) (i) splitting of a(n atomic) nucleus
do not accept splitting an atom 1
- (ii) Neutron 1
- (b) (i) nuclei have the same charge
or
nuclei are positive
accept protons have the same charge 1
- (ii) (main sequence) star
accept Sun or any correctly named star
accept red (super) giant 1
- (c) (i) any **two** from:
 - easy to obtain / extract
 - available in (very) large amounts

- releases more energy (per kg)
do not accept figures only
- produces little / no radioactive waste.
naturally occurring is insufficient
seawater is renewable is insufficient
less cost is insufficient

2

- (ii) any **one** from:
- makes another source of energy available
 - increases supply of electricity
 - able to meet global demand
 - less environmental damage
 - reduces amount of other fuels used.
- accept any sensible suggestion*
accept a specific example
accept a specific example

1

(d) 12

allow 1 mark for obtaining 3 half-lives

2

[9]

Q12.

(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]

Q13.

- (a) (i) 18

1

- (ii) the count rate for the source

1

- (iii) the alpha radiation would not cover such a distance

1

- (iv) plots correct to within $\frac{1}{2}$ small square
 allow 1 mark for 4 correct points plotted

2

correct curve through points as judged by eye

1

- (v) two attempts at finding 'half-distance' using the table

20 to 10 cpm $d = 0.4$ m

125 to 56 cpm $d = 0.2$ m

31 to 14 cpm $d = 0.4$ m

allow 1 mark for one attempted comparison

2

obeyed or not obeyed

dependent on previous two marks

1

- (b) (i) there is no effect on the count rate in experiment 1 because the field is
 parallel **or** beta particles are not deflected **or** there is no force

1

count rate is reduced in experiment 2 because field is perpendicular **or**

beta particles are deflected **or** there is a force

1

(ii) only background radiation (as beta do not travel as far)

1

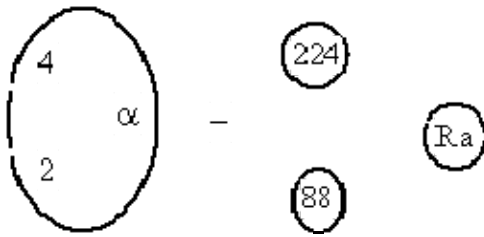
slightly different values show the random nature of radioactive decay

1

[13]

Q14.

(a)

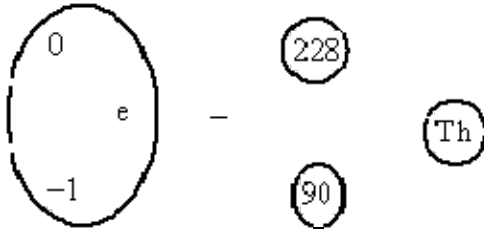


[Accept He²⁺ for α]

each  for 1 mark

4

(b)



[Accept β for e]

each  for 1 mark

4

(c) (i) beta/ β alpha/ α
alpha/ α beta/ β
beta/ β but alpha/ α
alpha/ α beta/ β

[i.e. consistent for 1; consistent and correct for 2]

gains 2 marks

2

(ii) *ideas that*

- many thorium atoms because they take so long to decay*
- (many lead atoms because) the thorium has been decaying for so long/for billions of years
- or** (because) the rock is so/very/billions of years of years old
- many lead atoms because this is the stable end product [of the decay series]

- few atoms of other isotopes because they decay so quickly*

[*N.B. credit answers in terms of half-life]

any three for 1 mark each

3

[13]

Q15.

(a) a uranium nucleus

1

absorbs a neutron

1

(uranium-236 nucleus) splits into two smaller nuclei

or

Kr and Ba nuclei

or

krypton and barium nuclei

1

and releases 3 neutrons and energy

1

(b) light nuclei

1

join to form a heavier nucleus

allow hydrogen nuclei for light nuclei

allow helium nucleus for heavier nucleus

1

(some of the) mass of the nuclei is converted to energy

allow particles for nuclei

1

(c) any **two** from:

- easy to obtain / extract
- available in (very) large amounts
- releases more energy (per kg)

do not accept figures only

naturally occurring is insufficient

seawater is renewable is insufficient

less cost is insufficient

allow produces little / no radioactive waste

2

[9]

Q16.

(a) (i) plutonium (239)

accept Pu / Thorium / MOX (mixed oxide)

do not accept uranium-238 or hydrogen

- (ii) (energy) used to heat water and
produce (high pressure) steam
the steam drives a turbine (which turns a generator)
- (b) Neutron(s) shown 'hitting' other U-235 nuclei
one uranium nucleus is sufficient
U-235 nuclei (splitting) producing 2 or more neutrons
- (c) any **two** from:
- neutrons are absorbed (by boron / control rods)
 - there are fewer neutrons
 - chain reaction slows down / stops
accept fewer reactions occur

1
1
1
1
1
1
2

[8]

Q17.

- (a) 78
- (b) atomic
- (c) (i) 131
correct order only
54
- (ii) 32 (days)
allow 1 mark for showing 4 half-lives provided no subsequent step
- (iii) limits amount of iodine-131 / radioactive iodine that can be absorbed
accept increases level of non-radioactive iodine in thyroid
do not accept cancels out iodine-131
so reducing risk of cancer (of the thyroid)
accept stops risk of cancer (of the thyroid)

1
1
1
1
2
1
1

Q18.

- (a) has an equal amount of positive charge
accept pudding/it is positive 1
- (b) (experimental) results could not be explained using 'plum pudding' model
or
(experimental) results did not support plum pudding model
accept (experimental) results disproved plum pudding model 1
- (c) (i) **A** – most of atom is empty space **or** most of atom concentrated at the centre 1
- B** – nucleus is positive (so repels alpha particles)
accept nucleus has the same charge as alpha 1
- C** – nucleus is very small
accept nucleus is positive if not scored for B
or
nucleus is a concentrated mass
accept nucleus has a very concentrated charge 1
- (ii) (if predictions correct, this) supports the new model
answers should be in terms of the nuclear model
accept supports his/new/nuclear theory
accept proves for supports
accept shows predictions/ Rutherford was correct 1

[6]

Q19.

- (a) beta 1
- alpha: would not pass through (the aluminium / foil) 1
- gamma: no change in count rate when thickness changes
must be a connection between detection / count rate / passing through and change in thickness 1
- (b) foil thickness increases then decreases (then back to normal / correct thickness)
a description of count rate changes is insufficient 1
- gap between rollers decreases, then increases (then back to correct size)
or

pressure from rollers increases then decreases
accept tightness for pressure
answers may link change in thickness and gap width for full credit ie:
foil thickness increases so gap between rollers decreases (1)
foil thickness decreases so gap between rollers increases (1)

1

(c) 56 (years)

accept any value between 55-57 inclusive
allow 1 mark for correct calculation of mass remaining as 1.5 (micrograms)
allow 1 mark for a mass of 4.5 micrograms plus correct use of graph with an answer of 12
maximum of 1 compensation mark can be awarded

2

[7]

Q20.

beta

reason may score even if alpha or gamma given

1

any **two** from:

- mass number does not change
or
 total number of protons and neutrons does not change
- atomic / proton number increases by 1
or
 number of protons increases by 1
- number of neutrons goes down by 1
allow for 2 marks a neutron splits / changes into a proton and electron / beta
*candidates that answer correctly in terms of why alpha **and** gamma are not possible, gain both marks*

2

[3]

Q21.

(a) isotopes

1

(b) ${}_{90}^{231}\text{Th}$

1

correct order only

1

(c) (i) (nuclear) fission

accept fision
*do **not** accept any spelling that may be confused with fusion*

1

(ii) neutron / neutrons

1

(d) plutonium (239)

accept MOX (mixed oxide)

accept Pu

*do **not** accept uranium 238 / hydrogen*

1

[6]

Q22.

(a) (i) (nuclear) fission

*accept fision providing clearly **not** fusion*

1

(ii) (released) neutrons are absorbed by further (uranium) nuclei

accept hit nuclei for absorbed / hit

*do **not** accept atom for nuclei*

1

more neutrons are released (when new nuclei split)

*accept for **both** marks a correctly drawn diagram*

1

(iii) increases by 1

or goes up to 236

1

(b) any **two** from:

• (more) neutrons are absorbed

accept there are fewer neutrons

• (chain) reaction slows down / stops

accept keeping the (chain) reaction controlled

• less energy released

accept heat for energy

accept gases (from reactor) are not as hot

2

[6]

Q23.

(a) (i) alpha

1

(ii) damages them / changes DNA

accept kills them / destroys

accept causes cancer
accept causes cell mutations
do not accept they ionise cells on its own

1

(b) count is (roughly) the same

1

gamma is not affected by magnetic field
accept magnet for magnetic field

1

or

alpha and beta are deflected by a magnetic field (1)
count would go down significantly (1)

(c) time taken for number of nuclei to halve

do not accept time for radioactivity to halve

or

time taken for count rate to fall to half
(its initial value)

do not accept time for nuclei to halve

1

(d) not enough time to take measurements / make observations

1

before level of radiation became insignificant

1

[7]

Q24.

(a) $1.2 = \frac{m}{2.3 \times 10^4}$

1

$m = 1.2 \times 2.3 \times 10^4$

1

$m = 27\,600 \text{ (kg)}$

allow an answer of 28 000 (kg) or $2.8 \times 10^4 \text{ (kg)}$

or

$m = 2.76 \times 10^4 \text{ (kg)}$

1

an answer of 27 600 (kg) scores 3 marks

(b) mass of air passing the turbine blades is halved which decreases kinetic energy by a factor of two

1

(wind speed is halved) decreasing kinetic energy by a factor of four

1

so kinetic energy decreases by a factor of eight

1

allow power output for kinetic energy throughout

(c) $388\,000 = 0.5 \times 13\,800 \times v^2$

this mark may be awarded if P is incorrectly / not converted

1

$$v^2 = \frac{(2 \times 388\,000)}{13\,800}$$

this mark may be awarded if P is incorrectly / not converted

or

$$v^2 = \frac{388\,000}{(0.5 \times 13\,800)}$$

or

$$v^2 = 56.2$$

1

$$v = 7.50 \text{ (m/s)}$$

an answer that rounds to 7.50 (m/s) only

1

[9]

Q25.

(a) chemical

1

equal to

allow the same as

1

in this order only

(b) $\text{power} = \frac{\text{work done}}{\text{time}}$

allow $P = \frac{W}{t}$

1

(c) $200 = \frac{W}{1800}$

1

$$W = 200 \times 1800$$

1

$$W = 360\,000 \text{ (J)}$$

- 1
- an answer of 360 000 (J) scores 3 marks*
- (d) $11 - 9.5 = 1.5$ (m/s) 1
allow a change in speed between 1.2 and 1.5 (m/s)
- $\left(\frac{1.5}{9.5}\right) \times 100 = 15.8$ (%) 1
- allow an answer consistent with their change in speed
an answer of 16 (%) scores 2 marks*
- an answer that rounds to 15.8 (%) scores 2 marks*
- (e) maximum speed is lower 1
- because maximum power output of cyclist is constant
allow maximum force on pedals is constant 1
- (but) additional work is done (against gravity)
*do **not** accept additional work done against friction or air
resistance*
- or**
gravitational potential energy (of cyclist) is increased 1
- [11]**

Q26.

- (a) g.p.e. = mass \times gravitational field strength \times height 1
accept $E_p = mgh$
- (b) $E_p = 50 \times 9.8 \times 20$ 1
- 9800 (J)
*allow 9800 (J) with no working shown for 2 marks
answer may also be correctly calculated using $W = Fs$
ie allow $W = 490 \times 20$ for 1 mark
or answer of 9800 (J) using this method for 2 marks* 1
- (c) 7840 (J) 1
allow ecf from '11.2'
- (d) $7840 = \frac{1}{2} \times 50 \times v^2$ 1

$$v = \sqrt{\frac{7840}{1/2 \times 50}}$$

allow $v^2 = \frac{7840}{(1/2 \times 50)}$ for this point

1

17.7(0875) (m / s)

1

18 (m / s)

allow ecf from '11.3' correctly calculated for 3 marks

allow 18 (m / s) with no working for 2 marks

answer may also be correctly calculated using $v^2 - u^2 = 2as$

1

(e) extension = 35 (m) and conversion of 24.5 kJ to 24500 J

1

$$24\,500 = \frac{1}{2} \times k \times 35^2$$

1

40

1

allow 40 with no working shown for 3 marks

an answer of '16.2' gains 2 marks

[11]

Q27.

(a) energy required to raise the temperature of a substance by 1 °C
accept heat for energy

1

unit mass / 1 kg

1

(b) (i) 7 140 000 (J)

allow 2 marks for a correct substitution, ie

$$E = 20 \times 420 \times 850$$

provided no subsequent step

850 gains 1 mark if no other mark awarded

3

(ii) particles in the air have more (kinetic) energy than the particles in the steel

allow particles in the air have a greater speed.

1

steel

particles vibrate (about fixed positions)

1

air

particles move freely

1

- (ii) the most energetic particles
accept molecules for particles throughout
accept the fastest particles 1
- have enough energy to escape from (the surface of) the water 1
- therefore the mean energy of the remaining particles decreases
accept speed for energy 1
- as energy decreased, temperature has decreased 1

[12]

Q28.

- (a) 4200

allow 2 marks for correct substitution

ie $6930 = 0.330 \times c \times 5.0$

answers of 1050 or 840

or

correctly calculated answer from correct substitution of incorrect temperature change

or

*identification of temperature change ie $5\text{ }^{\circ}\text{C}$
 gain 1 mark*

3

J / kg $^{\circ}\text{C}$

accept J / kg K

1

- (b) (in a metal) free electrons

to gain full credit the answer must be in terms of free electrons

1

gain kinetic energy

accept move faster

1

(free electrons) transfer energy to other electrons / ions / atoms

*do **not** accept particles*

1

by collision

allow a maximum of 2 marks for answers in terms of atoms / ions / particles

- *gaining kinetic energy or vibrating faster / more*
- *transferring energy by collisions*

1

- (c) (air) particles spread out 1
- (which causes the) air to become less dense / expand
do not accept particles become less dense 1
- (so the) warm air rises
do not accept heat rises
particles rise is insufficient 1
- (d) large surface area
ignore references to type of metal or external conditions 1
- black / dark (colour) 1
- [13]**

Q29.

- (a) conduction 1
- (b) (i) there is a bigger temperature difference between the water and the surrounding air
accept the water is hottest / hotter 1
- so the transfer of energy (from hot water) is faster
accept heat for energy
ignore temperature falls the fastest 1
- (ii) 120
allow 1 mark for converting kJ to J correctly, ie 4 032 000
- or**
- correctly calculating temperature fall as 8°C
- or**
- allow **2** marks for correct substitution, ie $4\,032\,000 = m \times 4200 \times 8$
 answers of 0.12, 19.2 **or** 16.6 gain **2** marks
 answers of 0.019 **or** 0.017 gain **1** mark 3
- (iii) water stays hot for longer 1
- so heater is on for less time
accept so less energy needed to heat water

1

so cost of the jacket is soon recovered from) lower energy costs / bills
accept short payback time

1

[9]