Unit 1 Physics EXAM

Question/Answer Booklet

PHYSICS

Written paper
Unit 1

Please place your student identification label in this box

Student Number: In figures ☐☐☐☐☐☐☐☐

In words ______________________________

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Time allowed for this paper

Reading time before commencing work:	Ten minutes
Working time for paper:	Two hours

Material required/recommended for this paper

To be provided by the supervisor

This Question/answer booklet; Formulae and constants sheet

To be provided by the candidate

Standard items: pens, pencils, eraser or correction fluid, ruler, highlighter

Special items: scientific calculator

Important note to candidates

No other items may be taken into the examination room. It is **your** responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room. If you have any unauthorised material with you, hand it to the supervisor **before** reading any further.

All calculations are to be set out in detail. Marks may be awarded for correct equations and clear setting out, even if you cannot complete the calculation. Express **numerical answers** to three (3) significant figures and include units where appropriate. Express **estimates** to one (1) or two (2) significant figures with units, and state any assumptions clearly.

Structure of this paper

Section of exam	Suggested working time	Number of questions	Number of questions to be attempted	Marks available
Section One	40 minutes	13	all	45
Section Two	65 minutes	6	all	60
Section Three	15 minutes	1	all	10
			[Total marks]	115

Note: the ‘overall’ section represents marks allocated to appropriate use of units and significant digits in final answers to numerical problems.

Instructions to candidates

1. The rules for the conduct of WACE examinations are detailed in the *Student Information Handbook*. Sitting this examination implies that you agree to abide by these rules.
2. Answer **all** questions in the spaces provided in this Question/Answer Booklet.
3. A blue or black ballpoint or ink pen should be used.

Section one: Short answer 45 marks

This section has **thirteen (13)** questions. Answer in the spaces provided.

Suggested working time: 40 minutes

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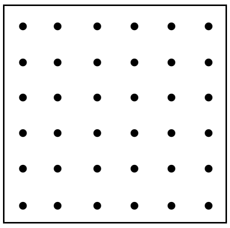
1. The diagrams below show a metal solid at different temperatures, the dots represent individual atoms. Which diagram would represent the solid at a higher temperature? Describe the physics behind your decision.

(3 marks)

Diagram A



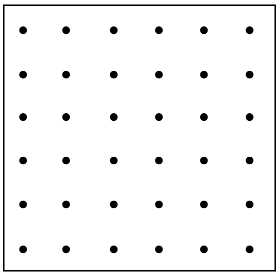


Diagram B

Diagram B would represent the metal at a higher temperature. (1 mark)
The space between atoms increases as the kinetic energy increases, due to the increased motion of the atoms. (2 marks)

2. Here is a collection of examples that contain heat energy that you may have encountered in daily life.

A) a bathtub with 100 litres of water at 20^{o} C
B) a sink filled with 10 litres of hot water at 90^{o} C
C) an oven filled with 1kg of hot, dry air at 200^{o} C
D) a 100g stainless steel heating element in a hair dryer at 150^{o} C

Using your knowledge gained during the course, use the letter of the real life situations above that best describes the following conditions: (no calculations required)

(5 marks)

a) Which has the highest temperature?
C

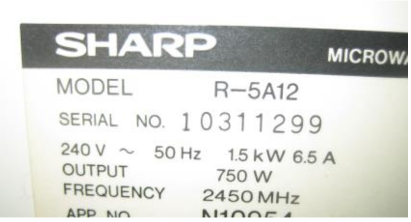
b) Which contains the most heat energy?
A

c) Which contains the least amount of heat energy?
D

d) Which has the highest average kinetic energy per atom?
C

e) Which would increase temperature the most if 1000J of energy were added?
D

3. The label on the right is a compliance plate found on an old microwave.



SHARP MICROW

MODEL	R–5A12
SERIAL NO.	10311299
240 V ~ 50 Hz	1.5 kW 6.5 A
OUTPUT	750 W
FREQUENCY	2450 MHz

a. Using the values given, calculate the resistance of microwave's internal circuitry.

(2 marks)

V = 240 V
I = 6.5 A
R = ?

V = I x R
R = V / I
R = 240/6.5
R = 36.9 Ω

b. Compare the input power to the output power. What is the efficiency and where does the lost energy go?

(2 marks)

P_{in} = 1500 W
P_{out} = 750 W

Efficiency = P_{out} / P_{in} x 100%
Efficiency = 750 / 1500 x 100%
Efficiency = 50%
50% of the energy is lost as other forms, sound, light, heat

4. A torch bulb has 2.35 Volts of potential difference applied across its contacts. What is the current flow if a charge of 16.8 Coulombs is moving across the bulb every minute?

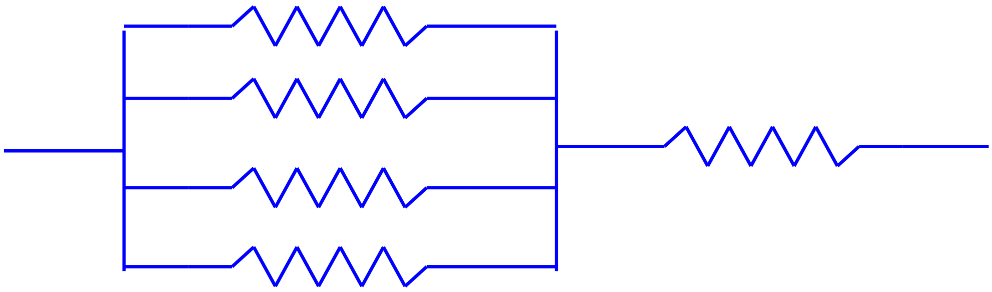
(2 marks)

V = 2.35 V
q = 16.8 C
t = 60 s

q = It
I = q/t
I = (16.8 x 60)
I = 0.280 A

5. Draw a diagram showing how you would connect a group of 4.00 Ω resistors (use as many as you need) to achieve an overall resistance of 5.00 Ω.

(2 marks)



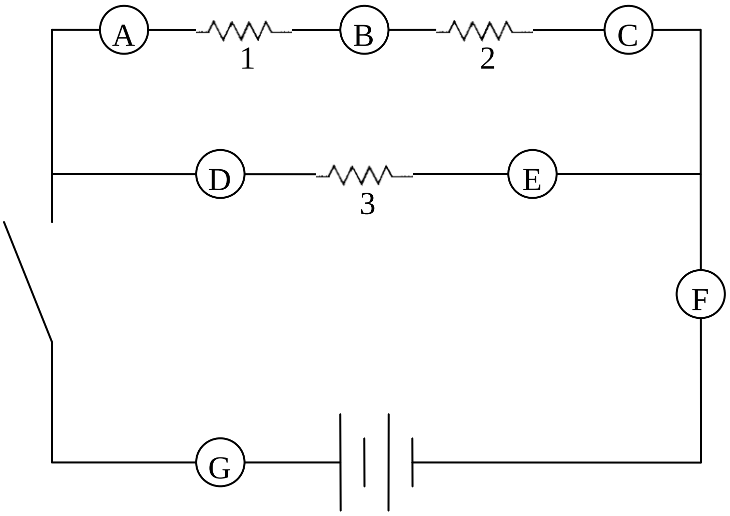
6. A picture of an expansion joint a road bridge is shown. Is this picture taken during a cold or warm day? Justify your answer using physics principles discussed in class.

(3 marks)

This picture is taken during winter, so it is *cold* (1). You can tell this from the joint being open (gap being wide) (1). When it is warmer, the kinetic energy of the particles (1) will increase causing the bridge to expand, closing the joint (lessening the gap).

7. The following circuit diagram shows the connections of three similar resistors (labelled 1, 2 and 3).

(4 marks)



a. The direction of conventional current flow is from

Circle the correct answer: [✓ G to A] B to A D to A

b. To determine the potential difference across resistor 2, you would use the points

Circle the correct answer: A and C A and F [✓ B and C]

c. There is no potential difference between the points

Circle the correct answer: [✓ A, D and G] A, B and C E, F and G

d. Comparing the amount of current going through points A, D and G, the order from the greatest amount of current to the least is

Circle the correct answer: A, D then G G, A then D [✓ G, D then A]

8. A kettle is brought to the boil from 25.0^{o}C and left boiling for 3.50 minutes. Half of the 1.250 litres of water boils away in that time leaving 0.625 litres boiling. How much energy has been converted?

(3 marks)

$Q_{Total} = Q_{heating} + Q_{Vaporisation}$
m_{water}?= 1.25 kg
m_g = 0.625 kg
$L_v = 2.25 \times 10^6$ Jkg^{-1}

$Q = m_{water}c\Delta T + m\ L_v$
$Q = 1.25 \times 4180 \times 75 + 0.625 \times 2.25 \times 10^6$
$Q = 3.92 \times 10^5 + 1.41 \times 10^6$
$Q = 1.80 \times 10^6$ J

9. A 75.0 W / 240 V light globe is left on for 10.0 hours, how much energy does it convert?

(3 marks)

P = 75.0 W
t = 10 x 60 x 60
t = 36000
V = 240 V

W = E = VIt
P = VI
E = Pt
E = 75.0 x 36000
$E = 2.70 \times 10^6$ J

10. A 21.7 g block of aluminium, which is initially at a temperature of 17.5 °C, is added to a 55.5 g copper calorimeter containing 153 mL of water at 60.0 °C. What is the final temperature of the aluminium block after the system has achieved thermal equilibrium? Assume no energy is lost.

(3 marks)

$$Q_{gained} = Q_{lost}$$
$$Q_{Al} = Q_{Cu} + Q_{Water}$$
$$mc(T_f - T_i) = mc(T_i – T_f) + mc(T_i – T_f)$$
$$0.0217x900(T_f – 17.5) = 0.0555x390x(60.0 – T_f) + 0.153x4180x(60.0– T_f)$$
$$19.53T_f – 341.7751298 =.7 - 21.645 T_f + 38372.4 – 639.54 T_f$$
$$680.715T_f = 40012.875$$
$$T_f = 58.8 °C$$

11. Jennifer was investigating the activity of 15.00 g of an unknown radioisotope. The original activity of the sample was 8.00 kBq and Jennifer had already determined that its half-life was four days.

a. What would its activity be 12 days later?

(2 marks)

A_0 = 8.00 kBq
Half-life = 4 days

$$n = \frac{\text{total time}}{\text{half - life}} = \frac{12}{4}$$

n = 3

$A = A_0 (½)^n$
$= 8.00 \text{ x } 0.5^3$

= 8.00 x 0.125

= 1.00 kBq

activity = 1.00 kBq (3sf)

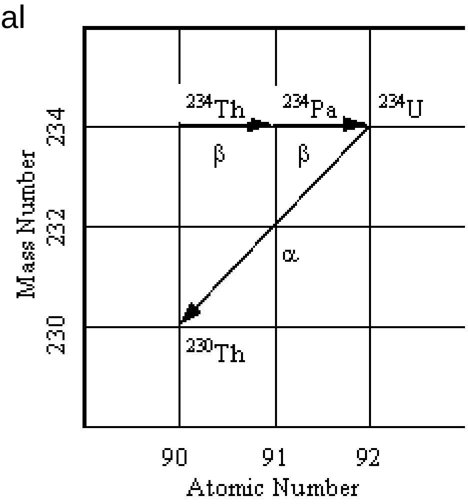
1 mark 'n' calculation
1 mark answer

b. Jennifer also had another 100 g sample of the same radioisotope. Would this second sample have a greater, equal or smaller half-life than the original 15.00 g sample of the radioisotope?

Circle the correct answer: GREATER [✓ EQUAL] SMALLER

(1 mark)

12. The graph to the right shows part of the natural Thorium-234 radioactive decay series, continuing as far as Thorium-230.



a. Write the nuclear transformation equations for each decay reaction shown on the graph.

(3 marks)

$$^{234}_{90}\mathrm{Th} \rightarrow {}^{234}_{91}\mathrm{Pa} + {}^{0}_{-1}\beta \text{ (or } {}^{0}_{-1}e\text{)}$$

$$^{234}_{91}\mathrm{Pa} \rightarrow {}^{234}_{92}\mathrm{U} + {}^{0}_{-1}\beta \text{ (or } {}^{0}_{-1}e\text{)}$$

$$^{234}_{92}\mathrm{U} \rightarrow {}^{230}_{90}\mathrm{Th} + {}^{4}_{2}\alpha \text{ (or } {}^{4}_{2}He\text{)}$$

b. For the above decays, Thorium -234 has a half life of 24.1 days, and Protactinium-234 has a half life of 6.75 hours.

(3 marks)

i. How does the weight of the same number of atoms of Thorium -234 compare to the same number of atoms Protactinium -234?

Circle the correct answer: GREATER [✓ EQUAL] SMALLER

ii. Given the same number of atoms of Thorium -234 and Protactinium -234, which sample would have the greatest number of decays per second?

Circle the correct answer: Thorium -234 EQUAL [✓ Protactinium -234]

iii. What happens to the weight of a sample of Thorium -234 when half of it has decayed to Protactinium -234?

Circle the correct answer: DOUBLES [✓ EQUAL] HALVES

13. After an animal dies it no longer takes in Carbon-14, so that the ratio of C-14 (radioactive) to C-12 (not radioactive) gradually decreases. C-14 undergoes β-decay and has a half-life of about 5730 years. The decay rate of C-14 in a living animal is around 15 decays/minute per gram of carbon. Toby and Oren, who are archaeologists, finds what they thinks is a dinosaur bone. The bone has a mass of 425 g of carbon. The β-decay rate from the whole bone is 50 decays/minute. What is the approximate age of the bone and based on this information, do you think Toby and Oren have a dinosaur bone (dinosaurs died out about 65 million years ago)?

(4 marks)

Living

15 x 425

= 6375 decays/min

Dead

= 50 decays/min

$A_o = 6375$ ***1 mark***

$A = 50$

Half-life = 5730 yrs

$$\frac{2^n}{1} = \frac{6375}{50}$$ ***1 mark***

$2^n = 127.5$

$2^n \approx 128$

n = 7 ***(note: while many students don't have the maths to handle $2^n = 128$, a simple trial and error approach will find the result reasonably quickly and this is intended as an A level question)***

total time = n x half-life

= 7 x 5730

= 40 110 years ***1 mark***

So no, not a dinosaur bone ***1 mark***

Section two: Problem-solving 60 marks

This section has **six (6)** questions. Answer in the spaces provided.

Suggested working time: 65 minutes

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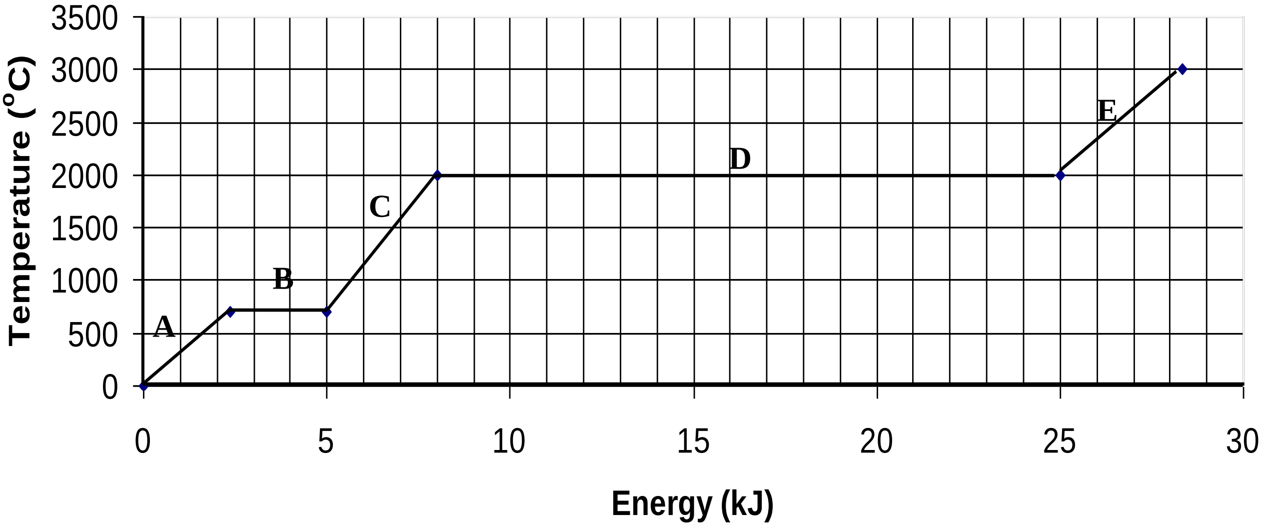
14. The graph below shows the change in temperature while heating a 20.0 g sample of an unknown solid. The total energy absorbed by the sample for each stage, A-E, is given below:

[9 marks total]



a) Which of the section(s) has the unknown material as a:

(3 marks)

i) Solid ____ A ____

ii) Gas ____ E ____

iii) Melting ____ B ____

b) Calculate the latent heat of vaporisation for this unknown material.

(3 marks)

Q = 25000-8000 = 17000J
$Q = mL_f$
$L_f = Q / m$
$L_f = 17000 / 0.020$ (1 correct value; 1 formula/rearrangement and numbers in)
$L_f = 8.5 \times 10^5$ J Kg^{-1}(1 answer)

c) Calculate the specific heat capacity of this material in the liquid phase.

(3 marks)

Q = 8000-5000 J
m = 0.020 kg
c = ?
$\Delta T = 2000-700$ °C

$Q = mc\Delta T$
$c = Q / M\Delta t$ (1 correct values)
$c = 3000 / 0.020 \times 1300$ (1 rearrangement and numbers in)
c =115 J Kg^{-1} K^{-1} (1 answer)

15. Alex is an industrial physicist who accidentally swallows a radioisotope with an activity of 10.0 kBq. The material swallowed has a very long half-life. You can assume therefore that the activity will not change appreciably during Alex's lifetime. Each decay of the isotope releases 1.60 x 10^{-13} J of energy into the body and that the radioisotope is not eliminated from the body.

[8 marks total]

a. Calculate the amount of energy absorbed in one non-leap year.

(3 marks)

Energy = activity x energy per decay x total time ***1 mark***

Total time
= 60 x 60 x 24 x 365
= 31536000 s

10 x 10^3 x 1.6 x 10^{-13} x 31536000 ***1 mark***
= 5.04576 x 10^{-2}

Energy = 5.50 x 10^{-2} J (3sf) ***1 mark***

b. If Alex has a mass of 70.0 kg, calculate the absorbed dose in one year.

(2 marks)

If using 0.100 J
AD = 0.1 / 70
AD = 1.43 x 10^{-3} Gy

Absorbed dose = $\frac{\text{energy}}{\text{mass}} = \frac{5.04576\text{x}10^{-2}}{70.0}$ ***1 mark***

$= 7.208142\text{x}10^{-4}$

Absorbed dose = 7.21 x 10^{-4} Gy (3sf) ***1 mark***

c. Assuming that the ingested radioisotope is an alpha emitter, what is the dose equivalent absorbed per year?

(2 marks)

If using 0.100 J
DE = 1.43 x 10^{-3} x 20
= 2.86 x 10^{-2} Sv

Dose equivalent = 20 x $7.208142\text{x}10^{-4}$ ***1 mark***
= 0.0144
Dose equivalent = 1.44 x 10^{-2} Sv (3sf) ***1 mark***

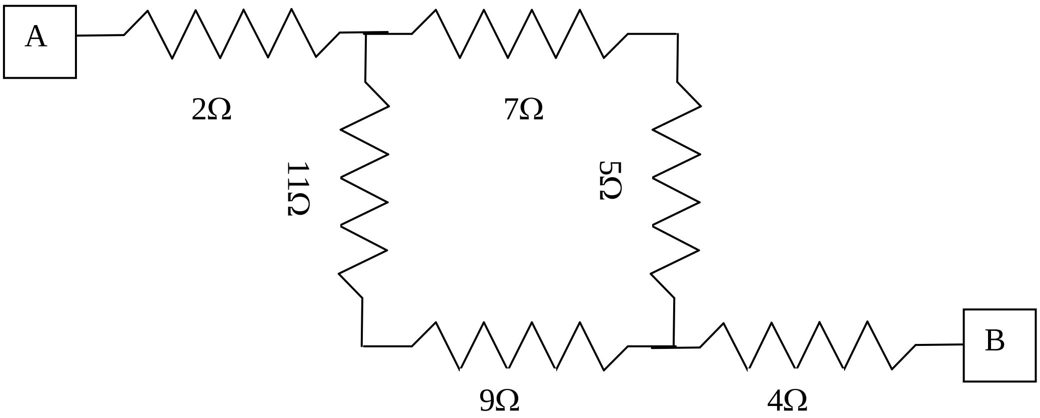
d. Should Alex be concerned about this yearly radiation exposure? Explain.

(1 mark)

No. This is a very low dose and would have no observable effects.

16. The following circuit is made with the resistors as shown.

[9 Marks Total]



a) What is the effective resistance from Point A to Point B?

(2 marks)

$R_T = 2 + ((7+5)^{-1} + (11+9)^{-1})^{-1} + 4$
$R_T = 2 + 7.5 + 4$
$R_T = 13.5\Omega$

b) If a potential difference of 24 volts is applied across this circuit from A to B, what current would flow?

(2 marks)

V=IR
I=V/R
I=24/13.5
I= 1.78A

c) What would the current flow be through the 9Ω resistor with the 24 volts applied?

(3 marks)

V=IR
V=1.78*7.5
V= 13.3 V across 11 Ω and 9 Ω
I=V/R
I=13.3/20
I= 0.667 A

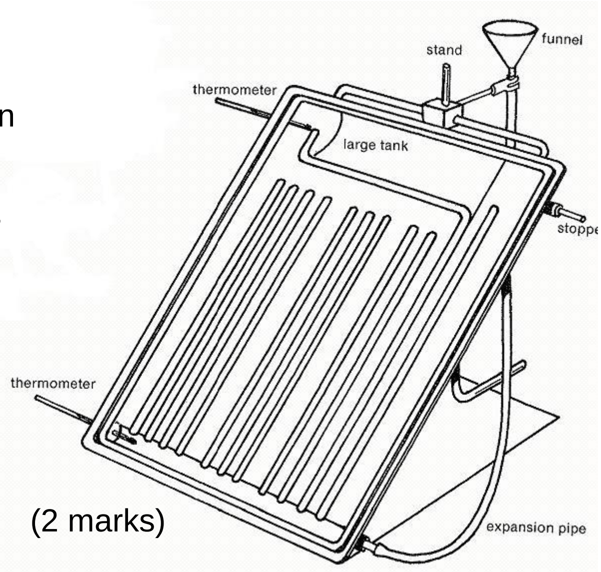
d) Using the resistors above, explain how you would rearrange the resistors above to create new circuits with the maximum and minimum resistance possible. (No calculation required)

(2 marks)

A maximum resistance circuit would have all of the resistors in series.
A minimum resistance circuit would have all of the resistors in parallel.

17. A student has set up an experiment designed on building a passive solar hot water heater. She designs the apparatus as shown, places it in a sunny area and records the temperatures. After an hour, the temperatures are recorded again. The thermometers are digital, with readings in whole numbers only (no decimals). The table has begun to be filled in.

[13 Marks total]



a) Complete the table.

(2 marks)

	Initial Temperature	Final Temperature	Temperature Difference
Top	20 ^{o}C	75 ^{o}C	55 ^{o}C
Bottom	20 ^{o}C	31 ^{o}C	11 ^{o}C

b) Explain why the water is warmer at the top of the apparatus, than at the bottom, at the end of the experiment. (Include Kinetic Theory for more marks)

(3 marks)

This is due to convection (1) were warmer water rises and colder sinks setting up a current (1). Warmer water becomes less dense as it increases in temperature and its kinetic energy per molecule increases, expanding the liquid (1).

c) The student has chosen to paint the apparatus black, explain why she has made this choice.

(2 marks)

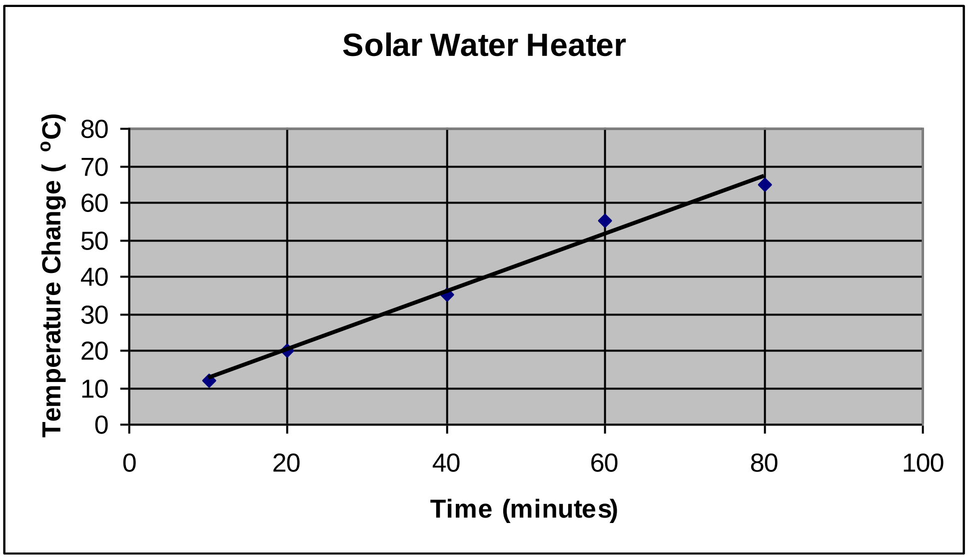
Radiation (1) is the main form heat input. Black has a high level of emissivity compared to other colours (absorbs the suns radiation well) (1).

d) Over the next few days, the student completed the experiment four more times. The results are shown on the table. Graph the results below.

Experiment	1	2	3	4	5
Time (minutes)	60	20	40	10	80
Temperature Change (^oC)	55	20	35	12	65

(3 marks)

Title/Labels(1)
Units (1)
Line graph (not Bar) with line of best fit(1)



e) What conclusion can be drawn about the relationship in the graph above?

(1 mark)

As the length of time increases the temperature increases proportionately.

f) If the initial temperature of the water was 17^oC, what would you expect the final temperature of the water to be after 50 minutes?

(2 marks)

$T_f = T_i + \Delta T$ $\Delta T = 43 - 47\,^oC$
$T_f = 17 + 45$
$T_f = 62^oC$ (60-64^oC for range of acceptable answers)

18. A year 12 Physics student is trying to find a quiet place to study, so moves into a shed in the back yard. He doesn't want to do without modern conveniences so gets a long extension cord from his parents' place to the shed. He uses a power board to plug in all the appliances. The shed now has 240V supplied to:

- 60W light bulb in a lamp
- 1000W bar heater
- 750W microwave

[10 Marks Total]

a) The power board has a fuse rated at 10A, does it trip if all of the appliances are turned on?

(3 marks)

P = 60 + 1000 + 750
P = 1810W
V = 240V
I = ?

P = VI
I = P/V
I = 1810/240
I = 7.54 A, No, the power board is OK

b) Calculate the resistance of the 750W microwave.

(3 marks)

P = 750W
V = 240V
R = ?

P=VI

V=IR
I = V/R

$P = V^2/R$
$R = V^2/P$
$R = 240^2/750$
R = 76.8 Ω

c) When all the devices are operating, how does the total resistance of the circuit compare to that of just the microwave? (No calculations required)

(1 mark)

Circle the correct answer: GREATER EQUAL [✓ SMALLER]

d) The element of the heater is a non - Ohmic conductor. Just after it is turned on it begins to increase in temperature and the current drawn changes. Use the Kinetic Theory to explain what happens to the current (and therefore resistance) as the element warms up to operating temperature.

(3 marks)

The current draw decreases (1)
The kinetic theory explains that as the temperature increases, the kinetic energy (motion) increases (1)
Electrons find it more difficult to move through the increasingly energetic particles, ie the resistance increases (1)

19. Uranium - 233 can undergo fission when struck by a thermal neutron producing many different types of splits. One possible split is shown in the following formula:

[11 marks total]

$${}^{1}_{0}\mathrm{n} + {}^{233}_{92}\mathrm{U} \rightarrow {}^{140}_{52}\mathrm{Te} + {}^{90}_{40}\mathrm{Zr} + \underline{\quad 4 \quad}\,{}^{1}_{0}\mathrm{n} + \text{energy}$$

a) How many neutrons are released during this fission process? (e.g. fill in the blank above.) (1 mark)

b) Given the atomic mass unit in the table for the above reaction, calculate the amount of the mass defect in kilograms for this fission process. (3 marks)

Isotope	**Mass (u)**
Neutron	1.008665
Uranium – 233	233.039635
Tellurium - 140	139.938854
Zirconium - 90	89.904708

M_d = (n + U-233) – (Te-140 + Zr-90 + 4n)
M_d = (1.008665 + 233.039635) – (139.938854 + 89.904708 + 4 x 1.008665) (1 mark)
M_d = 0.170 u (1 mark)
$M_d = 0.170 \times 1.6606 \times 10^{-27}$kg
$M_d = 2.82 \times 10^{-28}$kg (1 mark)

c) Calculate the energy released during the fission of one Uranium - 233 (${}^{233}_{92}\mathrm{U}$) atom. (If you were unable to determine the mass defect in (b), use the value 3.00×10^{-28}kg) (2 marks)

$E = mc^2$
$E = 2.82 \times 10^{-28} \times (3.00 \times 10^{8})^{2}$ (1 mark)
$E = 2.54 \times 10^{-12}$J (1 mark)

d) The first British atomic test in Australia on the 3rd of October 1952 on the Monte Bello Islands had a yield of 25 kt, or about 1 x 10^{15} J. Assuming the above energy release is the average per Uranium - 233 ($^{233}_{92}\mathrm{U}$) atom and was the main constituent, what mass of $^{233}_{92}\mathrm{U}$ atoms underwent fission during this test?

(3 marks)

Number of atoms needed = 1 x 10^{15} J / 2.54 x 10^{-12}J = 3.94 x 10^{26}atoms (1 mark)

Mass needed = 3.94 x 10^{26} x 233.039635 x 1.6606 x 10^{-27} (1 mark)

= 152 kg (1 mark)

e) This mass of Uranium - 233 is higher than the 'critical mass' value written in your text book. What does 'critical mass' mean, and how were the engineers able to transport this mass without the bomb going 'supercritical' and exploding at the assembly site?

(2 marks)

The minimum critical mass needs to be in a sphere, where enough neutrons are able to continue to incite fission. The mass was not transported together. In order to time the masses to go supercritical at once, they are held apart in sub critical amounts/shapes and then put together rapidly. Factors affecting criticality: mass, shape, temperature, neutron reflection or density. (1 for a factor of criticality, 1 for manipulation to gain super criticality)

Section three: Comprehension 10 marks

This section has **one (1)** question. Answer in the spaces provided.

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20. Recollections of my Grandmother

I remember many pleasant Sunday mornings sitting with my Grandmother as she told me stories of her life which was very different to mine. She loved to talk about when she was a young girl and learnt that her family was to move to the 'big city'. Hers was a large family and some of the younger children, herself included, had never been to Melbourne. She remembered being very excited about it.

There was such excitement when she arrived at her new home in Melbourne as it was equipped with electricity for lighting and gas for cooking, heating, so very modern and so very different from her country home. Some of the surrounding homes were still lit by gas mantels, gas stoves replaced the wood-fuelled ones (which had made kitchens so hot in summer) and small gas-heated water cisterns appeared on kitchen walls to service the sink. Washing was speeded up in gas-heated coppers and gas fires replaced the cheerful (but yet wasteful) wood fires in open fireplaces. Electricity was gradually appearing on the scene, but until probably well into the 1920s the normal suburban household was equipped with only one power point – usually for the electric iron. The socket had two holes only (no earth). She remembered when she first moved into their new house, her mother proudly showing her where the wonderful new electric iron was to be connected, by touching the socket with two of her fingers. Unfortunately she gave herself a nasty electric shock which gave everyone a good laugh later. With the current safety devices installed in our homes today, that is less likely to happen now.

She remembered that then there were no vacuum cleaners, electric blenders and other appliances we take for granted today, and she was the dish washer! The first electrical kitchen aids were the electric iron and toaster, and a small one-bar radiator for winter. With only one electrical outlet, double adapters boomed. Fitted into the central hanging light socket, one could connect a radiator or toaster, as long as the old fuses didn't blow! With the advent of other electrical implements, electricians must have reaped a small fortune rewiring houses and installing power points in every room. It was certainly different then.

a. Up until the 1920s, most homes only had one power point. What was this usually used for? (1 mark)

Electric iron [1 mark]

b. Early electrical homes had no earth wire. What is the purpose of an earth wire? (1 marks)

The earth wire is designed to carry away excess current from appliances in such cases as short circuits and to prevent current flowing through people.

c. Many appliances today such as hairdryers don't have an earth connection. Explain how are these appliances are made safe?

(2 marks)

Double insulation. **[1 mark]**

Not only are all internal conductors insulated with plastic, but appliance is also covered in plastic insulation – two layers of plastic so double insulation. **[1 mark]**

d. Name one electrical safety device in the home and explain how it works.

(2 marks)

Any suitable answer but probably fuse or circuit breakers.

FUSE:
Excess current causes wire to melt so circuit breaks and no current to cause damage. Wire must be replaced with similar type of fuse wire.

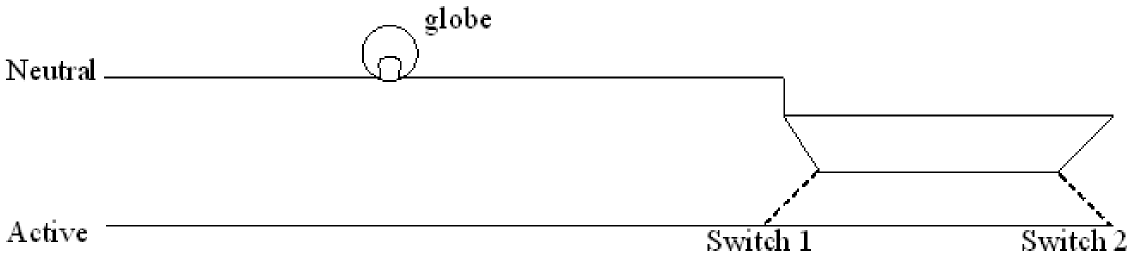
OR

CIRCUIT BREAKER:
Excess current causes electromagnetic switch to turn off and so breaks the circuit. No circuit so no current to cause damage. Need to push switch back on once problem fixed.

e. Modern homes have many power points and light switches. Often, one light can be controlled by two switches.

(1 mark)

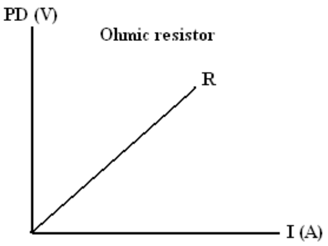
In the diagram below, is the light from the two-way switch on or off? _____**OFF**__________

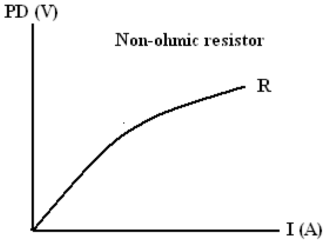


f. Light globes are non-ohmic resistors. Explain what this means. Include diagrams to help your explanation.

(3 marks)

In non-ohmic resistors, the potential difference is not proportional to the current. Often, as the potential difference is increased so does the temperature of the resistor and the resistance increases. **[1 mark]**
Ohmic resistors maintain a constant resistance over all ranges of potential difference and currents and heating doesn't affect their resistance. **[1 mark]**





[1 mark]

End of Examination