CHRIST CHURCH GRAMMAR SCHOOL

YEAR 11

PHYSICS ATAR

MID YEAR EXAMINATION 2017

1		
2		
3		
Total		/120 = %

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

Materials required/recommended for this paper
To be provided by the supervisor
This Question/Answer Booklet
Formulae and Data Booklet

To be provided by the candidate
Standard items: pens (blue/black preferred), pencils (including coloured), sharpener, eraser, correction tape/fluid, ruler, highlighters

Special items: non-programmable calculators approved for use in the WACE examinations, drawing templates, drawing compass and a protractor

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.

Structure of this paper

Section	No of Questions	No of marks	Proportion of exam total
1: Short Answers	6	40	33%
2: Problem Solving	6	60	50%
3: Comprehension	1	20	17 %
Total		120	100 %

INSTRUCTIONS TO CANDIDATES

Write your answers in the spaces provided beneath each question in each section.

Note that (where appropriate) answers should be given numerically to 3 significant figures and they should be evaluated and not left in fractional or radical form.

Questions containing specific instructions to show working should be answered with a complete, logical, clear sequence of reasoning showing how the final answer was arrived at. Correct answers which do not show working out will not be awarded full marks, despite a correct final answer.

Questions containing the instruction estimate may give insufficient numerical data for their solution. Candidates should provide appropriate figures to enable an approximate solution to be obtained.

Candidates should remember that when descriptive answers are required, they should be used to display understanding of the aims and objectives of the Year 11 ATAR physics course. A descriptive answer, which addresses the context of a question without displaying an understanding of physics principles, will not attract marks.

Despite an incorrect final result, credit may be obtained for method and working, provided these are clearly and legibly set out.

YEAR 11
ATAR PHYSICS
MID YEAR EXAMINATION 2017
Section One: Short Response

This section has **six (6)** questions. Answer **all** questions.
Write your answers in the space provided.

Suggested working time for this section is **40 minutes**.

Question 1 **(6 marks)**

(a) For each of the following numbers, indicate the absolute error in S.I. units.
(2 marks)

Measurement	Measured with:	Absolute error
25.0 cm	Ruler with cm divisions	0.5 cm = 5 x10^{-3} m
2.40 cm	Ruler with mm divisions	0.5 mm = 5 x10^{-4} m
155.3 g	Digital scale with 0.5% error	$155.3\times\frac{0.5}{100}$ = 0.7765 g = 7.765 x10^{-4} kg

* must be in S.I. Units. -1/2 marks

(b) A resistor is measured to have a voltage across it of 2.0 ± 0.1 V and a current through it of 0.50 ± 0.05 A. Calculate the percentage uncertainty of the resistance.
(2 marks)

R = $\frac{V}{R}$ = $\frac{2}{0.5}$

= 4.0 Ω

% unc (I) = $\frac{0.05}{0.5}\times100$ = 10%

% unc (V) = $\frac{0.1}{2}\times100$ = 5%

total: 10% + 5% = 15%

(c) Calculate the range of resistance due to the uncertainties of the measurements.

(2 marks)

R = $\frac{V}{R}$ = $\frac{2}{0.5}$

= 4.0 $\pm$ 15%

= 4.0 $\pm 4.0\frac{15}{100}$ = 4.0 $\pm 0.6\,\Omega$

Question 2 **(7 marks)**

(a) Explain why carbon-12 is a stable isotope of carbon but carbon-16 is a radioisotope.

(3 marks)

- Carbon 12 has a stable ratio of n:p
- Atoms up till Z = 20 (small atoms) have a ratio of 1:1
- Carbon 16 has too many neutrons and will decay

(b) Carbon-16 will decay via beta decay. Explain, using your knowledge of isotope stability, whether it will be beta positive or beta negative.

(3 marks)

1. β^-
2. Due to having too many neutrons, a neutron transmutates into a proton
3. And ejects a beta minus to conserve charge.

(c) Write the nuclear equation for the beta decay of carbon-16.

(1 marks)

$${}^{16}_{6}C \rightarrow {}^{16}_{7}N + {}^{0}_{-1}\beta + \bar{\upsilon}$$

-1/2 marks for no anti neutrino
0 for any arithmetic fault

Question 3 **(6 marks)**

A 0.120 kg piece of ice at -15.0 °C is placed into a 0.300 kg aluminium calorimeter containing 0.400 kg of water both of which are at 35.0 °C. Assuming no energy losses, calculate the final temperature of the mixture. $C_{Al} = 880 \text{ Jkg}^{-1}\text{K}^{-1}$.

$Q_g + Q_L = 0$

$m_i c_i \Delta T_i + m_i L f + m_{iw} c_{iw} \Delta T_{iw} + m_w c_w \Delta T_w + m_c c_c \Delta T_c = 0$

$0.120(2100)(+15) + 0.120(3.34\text{x}10^5) + 0.12(4180)T_f + 0.4(4180)(T_f) - 0.4(4180)(35)$

$+ 0.3(880)\ T_f - 0.3(880)(35) \quad = 0$

$3780 + 40080 + 501.6\ T_f + 1672\ T_f - 58520 + 264\ T_f - 9240 = 0$

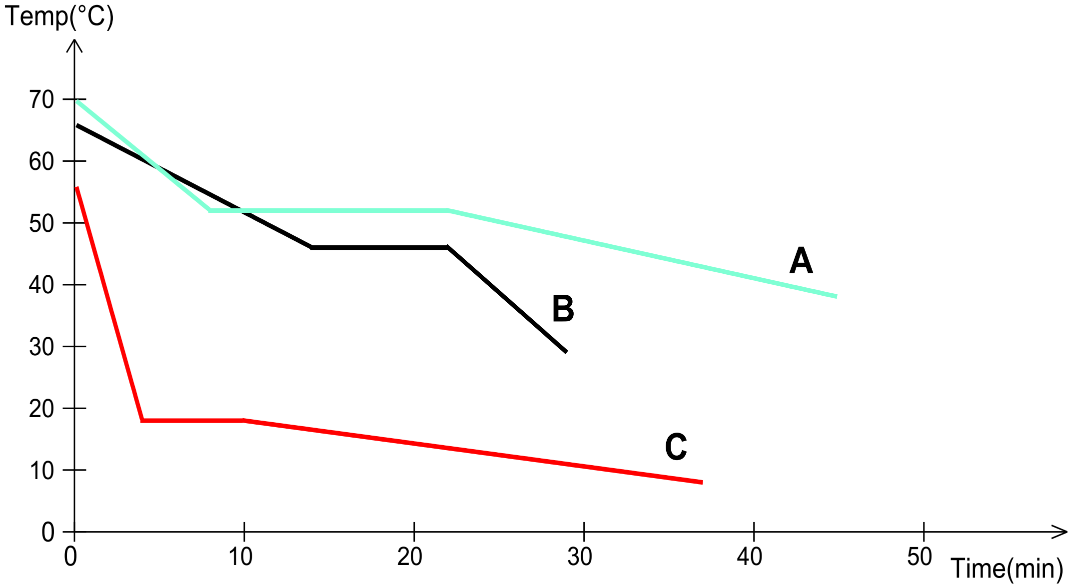
$2437.6\ T_f = 23900$

$T_f = \frac{23900}{2437.6}$

$= 9.80\ °C$

Question 4 **(7 marks)**

Thomas heated three solids A, B and C until they melted. They were then placed in a refrigerator where energy was removed at a constant and equal rate for all three substances. A copy of the cooling curve is shown below. The experiment was stopped after all three substances were solid. Equal masses of solids A, B and C were used.



(a) Which solid has the highest melting point? What is the approximate numerical value of this temperature?

(1 marks)

A 53 °C

(b) Which solid has the largest specific heat capacity? Explain fully, your reasoning.

(3 marks)

1. C
2. The gradient (rate of change of temperature) is the lowest
3. Gradient is proportional to $\frac{\Delta T}{Q}$, which is the inverse of c (proportional to $\frac{Q}{\Delta T}$)

(c) Determine, by what factor, substance A's Latent Heat of fusion is compared to substance B's. Show all your logic and working.

(3 marks)

A time = 22 – 8 = 14 min ½

B time = 22 – 14 = 8 min ½ Time ∝ Energy

LfA : LfB = 14:8 ½

= 1.75x 1

-1 for no lines/working shown on graph

Question 5 **(8 marks)**

It is estimated that the annual dosage due to cosmic radiation at sea leve is 6.00×10^{-4} Sv with an additional 1.50×10^{-1} Sv per km above sea level.

(a) Determine the annual equivalent dosage for a person living at 2.50 km above sea level.

(2 marks)

E.D = $6 \times 10^{-4} + 0.15 \times 2.5$

= 0.376 Sv

(b) If a 70.0 kg man absorbs 2.63 joules of energy in a year at this altitude, calculate the average quality factor of the cosmic radiation.

(3 marks)

A.D. = $\frac{E}{m} = \frac{2.63}{70.0} = 0.0376\ Gy$

Q.F. = $\frac{E.D}{A.D} = \frac{0.376}{0.0376} = 10.0$

(c) Explain why the absorbed dose of cosmic radiation increases as a function of height above sea level.

(3 marks)

- Atmosphere contains gases which absorb the energy of the radiation
- At higher elevations above sea level, there is less atmosphere to shield a person
- The energy absorbed by a person and hence absorbed dose increases.

Question 6 **(6 marks)**

Uranium-238 is a radioactive isotope that transforms into a series of different isotopes by sequentially emitting alpha and beta particles. The daughter product of each decay is itself radioactive. This is called a decay series. U-238, after many decays, eventually becomes a stable isotope of lead.

(a) Using alpha and beta decays only, explain how you could convert U-238 into Ac-230. (Hint it requires three separate decays.)

(3 marks)

$$^{238}_{92}U \rightarrow \, ^{234}_{90}Th + \, ^{4}_{2}\alpha$$

$$^{234}_{90}Th \rightarrow \, ^{230}_{88}Ra + \, ^{4}_{2}\alpha$$

$$^{230}_{88}Ra \rightarrow \, ^{230}_{89}Ac + \, ^{0}_{-1}\beta + \bar{\upsilon}$$

½ mark each for α , α, β can be any order (= 1.5)

½ mark each for correct equations (= 1.5)

(b) The half-life of uranium-235 is 7.04 x10^8 years. If a sample of uranium-235 extracted from an ore was found to have an activity of 3.55 x10^1 Bq, determine how long ago it's activity was 5.68 x10^2 Bq.

(3 marks)

$$\frac{A}{A_0} = \frac{35.5}{5.68\times10^2} = \frac{1}{16} = \frac{1}{2^4} \quad \therefore n = 4$$

t = n x $t_{1/2}$

= 4 x 7.04 x10^8

= 2.82 x 10^9 years

End of Section One

YEAR 11
ATAR PHYSICS
MID YEAR EXAMINATION 2017
Section Two: Problem Solving

This section has **six (6)** questions. Answer **all** questions.
Write your answers in the space provided.

Suggested working time for this section is **60 minutes**.

NAME:____

TEACHER: CJO JRM
(please circle)

Question 1 **(10 marks)**

Fuorine-19 has an atomic mass of 18.998404 u.

Name	Mass of atom (u)
Proton	1.007 276
Neutron	1.008 665
Electron	0.000 548 58
Hydrogen	1.007 825

(a) Calculate the mass defect of fluorine-19 in both atomic mass units and kg. Express your answer to 3 significant figures. (4 marks)

m.d. = Z x m(^{1}H) + N x m(n) – m(isotope) 1

= 9x1.008 665 + 10x1.007 825 – 18.998404 ½

= 0.158671 u 1

x 1.60 x10^{-27} ½

= 2.63 x 10^{-28} kg 1

(b) Calculate the binding energy in joules for fluorine-19. (3 marks)

E = mc^2

= 2.63 x 10^{-28} (3x10^8)^2

= 2.37 x10^{-11} J

(max of 2 marks for MeV not J)
Using MeV
Be = md x 931
= 147.7 MeV
147.7 x 1.6 x 10^{-13}= 2.36 x 10^{-11}J

(c) Explain what the physical meaning of the value in part (b) represent for the nucleus.

(1 mark)

Energy required to rip the nucleus into its constituent parts

OR

Energy required to be extracted to bind all components of the nucleus together

(0.5 marks only for "energy to bind components of nucleus together")

(d) Calculate the binding energy per nucleon for fluorine-19 in joules per nucleon.

(2 marks)

B.E / nucleon = B.E. / mass number ½

$$= \frac{2.37 \times 10^{-11}}{19}$$ ½

$= 1.25 \times 10^{-12}$ J / nucleon 1

(Max of 1 mark for using MeV)

Question 2 **(7 marks)**

A piece of copper metal initially at 1.00×10^{2} °C is submerged in 0.600 kg of insulated water at a temperature of 25.0 °C. C_{cu} = 390 $Jkg^{-1}K^{-1}$.

(a) Calculate the mass of the copper if the final temperature of the mixture is measured to be 45.0 °C.

(4 marks)

$Q_g + Q_L = 0$ ½

$m_w c_w \Delta T_w + m_c c_c \Delta T_c = 0$ ½

$$m_c = \frac{-m_w c_w \Delta T_w}{c_c \Delta T_c}$$

(2 marks for working out)

$$= \frac{-0.600(4180)(45-25)}{390(45-100)}$$

= 2.34 kg 1

(-1 for any mistake in working, -1 for not getting final correct answer)

(b) Explain, with reference to an appropriate mixtures equation, by what factor the required mass would change if aluminium at 1.00×10^{2} °C was used intead of copper and placed in the same water as a).
$C_{Al} = 880\ Jkg^{-1}K^{-1}$.

(3 marks)

$$m_c = \frac{-m_w c_w \Delta T_w}{c_c \Delta T_c}$$

$$m_c \propto \frac{1}{c_c} \qquad \frac{m_a}{m_c} = \frac{c_c}{c_A}$$

$$= \frac{390}{880} = 0.443x$$

(max one mark if equations not shown and numberical response only)

(1 mark answer, 2 marks appropriate justification wrt equations)
(1 mark calculating mass of Al, 1.036kg)

Question 3 **(15 marks)**

On average, 195 MeV is released in each fission event of uranium-235.

(a) Calculate the average energy released per fission event in Joules.

(2 marks)

$E = 195 \times 1.60 \times 10^{-13}$

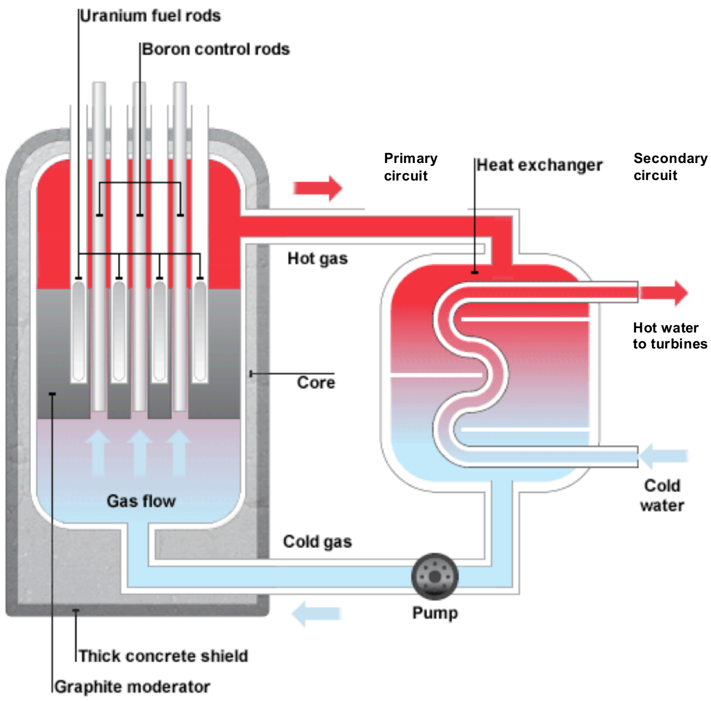
$= 3.12 \times 10^{-11}$ J

(b) Xenon-140 was identified as being produced along with 3 neutrons, determine the other fission fragment produced.

(2 marks)

$${}^{235}_{92}U + {}^{0}_{1}n \rightarrow {}^{140}_{54}Xe + 3\,{}^{1}_{0}n + {}^{93}_{38}Sr$$

A diagram of a typical nuclear fission power plant is shown.



(c) Explain the role of the following structures:

i. Moderator

(1 mark)

Slow down fast moving neutrons

So they can be captured by fissile nuclei

ii. Control rods

(1 mark)

Control the rate of fission

by absorbing thermal neutrons.

iii Heat Exchanger

(1 mark)

Transfer energy from the reactor to the turbine in order to generate electricit

(d) If a nuclear reactorevents /s requires 1.00 x10^8 W released via fission events in the reactor, calculate the number of fission events that needs to occur per second. (If you could not answer (a), use E = 2.00 x10^{-11} J)

(3 mark)

3.12 x10^{-11} J n^{-1}

$$n = \frac{E}{En^{-1}} = \frac{1.00 \times 10^{8}}{3.12 \times 10^{-11}}$$

= 3.21 x10^{17} events / s

(½ mark only for P=E/t)

When the power plant is running, the heat exchange operates at 65.0% efficiency. Water at 21.5 °C flows into the heat exchange and exits at 255 °C. The water is under pressure so does not boil but instead, remains as a liquid.

(e) Calculate the flow rate (in kgs^{-1}) of water that flows through the secondary circuit of the heat exchanger. Assume: 100% of the energy produced by the reactor reaches the heat exchanger and c_{water} = 4180 $Jkg^{-1}K^{-1}$

(5 marks)

$P_{useful} = P_{total} \times \frac{\varepsilon}{100}$ 1

$= 1.00 \times 10^8 \times \frac{65}{100}$ ½

$= 6.50 \times 10^7 \text{ Js}^{-1}$ 1

$m/t = \frac{Q/t}{c\Delta T}$ 1

$= \frac{6.50 \times 10^7}{(4180)(255-21.5)}$ ½

$= 66.6 \text{ kgs}^{-1}$ 1

Question 4 **(6 marks)**

An Apple iWatch operates with a voltage of 5.00 V and draws an operating power of 4.50 mW.

(a) Calculate the total number of electrons that pass through a point in the watch if it operates for 3.00 hours.

(4 marks)

$q = It$ ½ $I = \frac{P}{V}$ ½

$= \frac{P}{V} . t$ ½

$= \frac{4.5 \times 10^{-3}}{5} \times (3 \times 60 \times 60)$ -1 mark for not showing conversion to seconds

$= 9.72$ C ½

$n = \frac{q}{e^-} = \frac{9.72}{1.60 \times 10^{-19}} = 6.08 \times 10^{19}$ electrons 1

½ ½

When the iWatch is charging for a period of 5.50 hours with the same voltage, the battery provides 0.690 kJ of energy in electrical potential by moving charge back through the battery.

(b) Determine the amount of charge that moves through a point in the watch during this time.

(2 marks)

$W = qV$ $q = \frac{W}{V}$ ½

$= \frac{0.690 \times 10^{3}}{5}$ ½

$= 138$ C 1

(0.5 for calculating current)

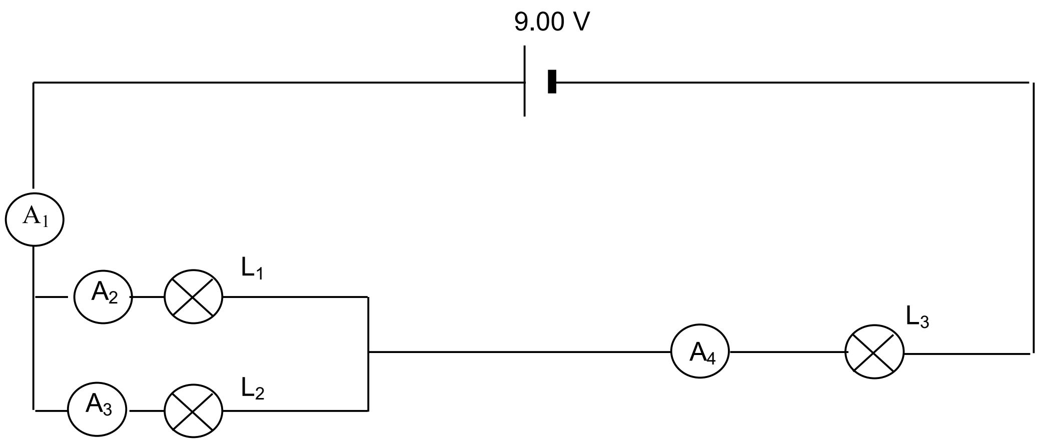
Question 5 **(16 marks)**

Three globes are connected in the arrangement shown with ammeters A1 to A4 placed in the circuit as indicated. The resistances of the globes are:

$L_1 = 10.0\ \Omega$

$L_2 = 15.0\ \Omega$

$L_3 = 10.0\ \Omega$



(a) Calculate the total resistance of the circuit.

(3 marks)

$$\frac{1}{R_E} = \frac{1}{15} + \frac{1}{10}$$

$$= \frac{2}{30} + \frac{3}{30}$$

$$= \frac{5}{30} \qquad \therefore R_E = \frac{30}{5} = 6\ \Omega$$

$R_T = R_E + R_3$

$= 6 + 10$

$= 16.0\ \Omega$

(b) Determine the voltage across the 15.0 Ω globe.

(4 marks)

$I_T = \frac{\varepsilon}{R_T} = \frac{9}{16} = 0.563A$ (2 marks total)

$V_P = I_T.R_E$

$= 0.563 \times 6$

$= 3.38\ V$

(2 marks total, no marks for equations)

(c) Calculate the current reading on all ammeters

(3 marks)

$I_T = I_1 = I_4 = 0.563A$

$I_2 = \frac{V_P}{R_1} = \frac{3.38}{10} = 0.338A$

$I_3 = \frac{V_P}{R_2} = \frac{3.38}{15} = 0.225A$

(d) Calculate the number of electrons that flow through Globe 3 in 3.00 minutes

(3 marks)

$q = I_T . t$ ½

$= 0.563(3x60)$ ½

$= 101$ C ½

* - 1 marks for not showing conversion to seconds

$n = \frac{q}{e^-}$

$= \frac{101}{1.60\times10^{-19}} = 6.33x10^{20}$ electrons

½ 1

(b) If L_3 was removed from the circuit, explain qualitatively how the brightness of the remaining globes would be affected. Include appropriate equations to support your answer.

(3 marks)

- If R_3 is removed, R_T will decrease as it is in series.
- This will increase I_T and hence, the current flowing through the other globes
- As $P = I^2R$, the power/brightness of the globes will increase

Question 6 **(6 marks)**

Steam burns pose a significant safety hazard to humans. In a factory, 125 grams of steam at 120.0°C is vented and condenses into liquid water at 40.0 °C.

(a) Calculate the heat released in the above event.

(3 marks)

$Q = mc\Delta T + mL_f + mc\Delta T$

$= 0.125(2000)(100\text{-}120) - 0.125(22.6\text{x}10^5) + 0.125(4180)(40\text{-}100)$

$= -5000 – 282{,}500 – 31{,}350$

$= -318{,}850$ J (removed)

If mistake in working is made, no follow through for answer.
If one heat transfer is forgotten, ½ mark awarded for equation.

(b) Explain why steam at 100 °C poses a more significant safety hazard than liquid water at 100 °C

(3 marks)

- Steam contains a much higher amount of internal energy due to its gaseous state.
- If steam comes into contact with someone, it has far more energy to transfer inorder to cool to the final equilibrium temperature
- This larger amount of energy will cause more severe burns to human tissue.

End of Section Two

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YEAR 11
PHYSICS ATAR
MID YEAR EXAMINATION 2015
Section Three: Comprehension

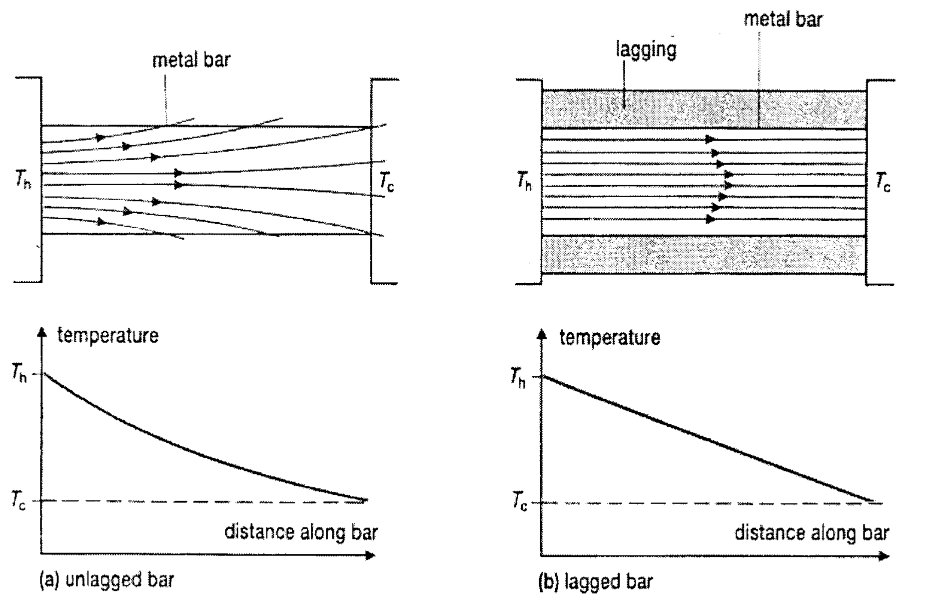
This section has **one (1)** question. Answer **all** questions. Write your answers in the space provided.

Suggested working time for this section is **20 minutes.**

Question 1 **(20 marks)**

Thermal Conductivity

If a bar of metal is placed so that one end of it is in contact with an object kept at a high temperature and the other end kept in contact with an object at a low temperature, then heat will flow through the rod. How much heat flows depends on additional factors. If the bar is cold when it is placed in position then to begin with the temperature of the bar will rise at the hot end. Heat will flow towards the cold end and this will gradually raise the temperature of the bar, but it is never possible for the whole of the bar to reach the temperature of the hot object. When the temperature of each part of the bar has stopped rising, the bar is said to be in the steady state. No heat will subsequently be used to raise the temperature of the bar itself. The final temperature achieved at different points along the bar will depend on how the bar is lagged, as shown in the diagrams below.



Heat flow through a lagged and an unlagged bar. The temperature gradient is constant along a bar from which heat does not escape.

If heat escapes through the sides of the bar, then there is a greater flow of heat through the bar near the hot end than there is through the cold end. This means that there must be a larger temperature gradient near the hot end than near the cold end. The variation of temperature with distance is not linear. If perfect heat insulation is imagined around the bar, then no heat escapes through the sides and the rate of heat flow must be the same at all points along the bar. This parallel flow of heat in the steady state implies that the temperature gradient must be constant.

In the steady state it is found experimentally that the rate of flow of heat, Q/t, depends on the material of the bar and is proportional to:

the cross-section area of the material “A”

the temperature gradient

For parallel flow, the temperature gradient is the difference in temperature between the ends of the bar divided by L, the length of the bar. Here it does not matter whether the temperatures are measured in Kelvin or degree Celsius. A temperature difference is normally quoted in Kelvin even though it is likely that when measurements are made of the temperatures at the ends of the bar the readings are taken in degrees Celsius.

If T_h is the Kelvin temperature at the hot end of the bar and T_c the temperature at the cold end then

$$\frac{Q}{t} = \frac{\sigma A(T_h - T_c)}{L}$$

where σ is a constant called the thermal conductivity of the material.
σ is a constant which has units. To find the SI unit, ρ can be made the subject of the equation giving:

$$\sigma = \frac{Q}{t}\frac{L}{(T_h - T_c)}$$

Some numerical values of ρ for some common substances are given in the table below

Material	Thermal Conductivity
Metals	
aluminium	205
brass	109
copper	385
silver	406
steel	50
Typical domestic materials	
cotton poplin	0.048
interlock wool	0.040
velour coating	0.040
cellular cotton	0.050
woollen blanketing	0.037
carpet	0.050
Typical building materials	
brick	0.6
insulating brick	0.15
concrete	0.8
glass	0.8
fibreglass	0.04
insulating foam	0.01
soft wood	0.1
Gases	
air	0.024
hydrogen	0.14
oxygen	0.023

a) Why does it not matter if the temperature of parallel flow is measured in Kelvin or degrees Celsius?

(2 marks)

When subtracting (finding a difference) units are equivalent
An inrease in One celsius degree is the same as 1 Kelvin.

b) Determine the SI units for thermal conductivity.

(2 marks)

J s^{-1} m^{-1} k^{-1}

c) Which of the graphs (a) unlagged bar or (b) lagged bar represents flow of heat in the steady state? Explain your answer.

(2 marks)

Both bars are in steady state.
The temperature at any point on either bar is constant.

d) If an unknown material which has a cross sectional area of 10^{-3} m^2, a temperature gradient of 50 K, a length of 0.1 m and a heat rate flow of 100 J s^{-1} is tested is the material more likely to be a metal or a gas? Support your answer with a calculation.

(4 marks)

$\sigma = \frac{100\times0.1}{50\times10^{-3}} = 200$ J s^{-1} m^{-1} K^{-1} (1 working, 1 answer)

The material is more likely to be a metal because it compares with the values quoted in the table of thermal conductivities.
(1 metal) (1 justification)

e) What is the function of the "lagging"?

(2 marks)

To insulate from surroundings (surrounding with an ins\ulator)

The lagging reduces the energy loss to surroundings.

e) Why is it not possible for the whole of the bar to reach the temperature of the hot object?

(2 marks)

Heat will always transfer from hot to cold, energy wll constantly be transferred to colder object

As the bar is in contact with two different temperatures it can never reach **thermal equilibrium.**

f) In the context of the article, explain what is meant by the term "steady state".

(2 marks)

Steady state means the temperature at any point on the bar is constant.
Heat gained equals heat lost at that point.

g) Explain in terms of the kinetic theory of matter, why the thermal conductivity of air is 0.024 but the thermal conductivity of brass is 109.

(3 marks)

The particles in brass are linked by strong bonds and are relatively close together compared to air.

This makes conductivity between the particles easier in brass as particles can more easily collide, transferring Ek.

The particles in air on the other hand are at greater distances so conductivity is more difficult.

h) Compare the thermal conductivities of silver and copper and explain why copper is used instead of silver in situations where high conductivity is required.

(1 mark)

The conductivities of silver and copper are similar with silver having a slightly higher thermal conductivity. Silver is not used as much as copper because it is expensive.

End of Section Three