PHYSICS - 5054

ATP SESSION 3.1

REVIEW NOTES

THERMAL, ELECTRICTY AND MAGNETISM

With Practice Questions and Marking Schemes

Sir M. Kashan Rashid

0342-2578410

Physics by Kashan Rashid

Current Electricity

Ammeter

A device used to measure the current flowing in a circuit. The device is always attached in series with the component of which current is to be determined. Attaching the ammeter in parallel to the component will short the circuit as current will not pass through the resistor. Ammeter is of negligible resistance.

Galvanometer

It is called a sensitive ammeter and is also used to measure the direction of current flowing through the component. Where ammeters are used to measure in amperes, the galvanometer is used to measure in mA.

Voltmeter

A device used to measure the potential difference across the load. It is always attached parallel to the component so that difference is potentials can be measured. Attaching the voltmeter in series would break the circuit as voltmeter has very high resistance (sometimes referred as infinite resistance).

For correct readings

1. To measure the reading on the ammeter or voltmeter, make sure to avoid parallax error by keeping the line of sight perpendicular to the markings.
2. It must also be noted that the meters should not have zero error. To check for zero error, check if the needle of the meter coincides with the zero of the scale when not in use.
3. Tap the meter before attaching the wires to check if the needle is freely moving.
4. Wait for the needle to get stationary before taking the reading.

For marking the reading on a meter

1. Make a point arrow head to mark the reading on the meter.
2. Use a ruler to locate the reading for precise pointing

Crocodile Clips

The clips are used to connect electrical components with one another. The clips ensure firm and proper contact of components and also provide easy attachment and detachment. These clips are joined at the end of wire.

Resistor

An electronic component that is used to control the amount of current flowing in the circuit. Resistors can be fixed or variable based on their construction.

Rheostat

A type of a variable resistor whose resistance depends upon the change in length of the conductor. The greater the length, the higher would be the value of the resistance.

Jockey

Jockey is an arm that is used to connect one end of the circuit to the other at any location. It is usually used with a long length of wire whose resistance is to be varied with length.

LDR

Abbreviation of Light Dependent Resistor. Its resistance varies inversely with light intensity. It is used in potential divider circuits.

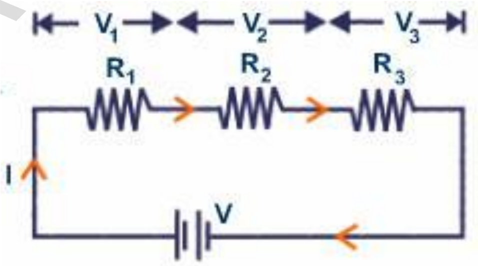
Thermistor

It is a temperature dependent resistor whose resistance varies inversely with temperature. It is used in potential divider circuits.

Resistors in Series

Total resistance of the resistors attached in series is equal to the sum of individual resistances of the resistors. Mathematically,

$R_T = R_1 + R_2 + R_3 .... + R_n$ where n = no. of resistors in series



Current in a series circuit remains same i.e. the current passing through all the resistors is same.

$$I = I_1 = I_2 = I_3$$

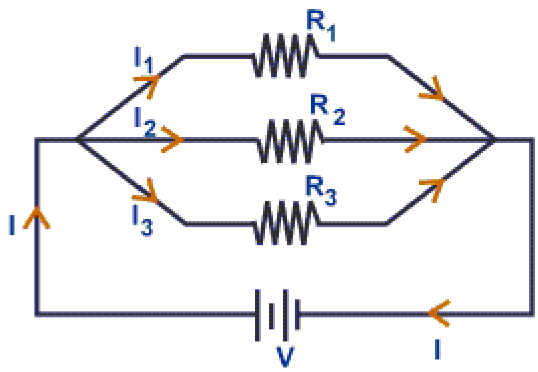
Although the resistors don't carry the same potential difference. The sum of the potential differences on the resistors in series is equal to the EMF i.e. voltage of the battery.

$$V = V_1 + V_2 + V_3$$

Resistors in Parallel

Reciprocal of total resistance of the resistors is equal to the sum of reciprocal of individual resistances. Mathematically,

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \dots \dots . + \frac{1}{R_n}$$



The current is distributed in the resistors. Total current in the circuit is equal to the individual currents passing through each resistor in parallel.

$$I = I_1 + I_2 + I_3$$

The potential difference is same on all the resistors attached across the voltage source.

$$V = V_1 = V_2 = V_3$$

Troubleshooting Circuits

If a circuit is not working, following could be the possibilities

1. The connecting leads are broken or worn out.
2. Battery is of a lower potential than required.
3. Battery is weak
4. Bulb is already fuse
5. Bulb or component of a higher voltage requirement
6. Switch is faulty
7. If LED bulb is used, reverse connection of battery will also not let the bulb lit

Safety Measure with electricity experiment

In order to ensure safe handling while performing electrical experiments, following measures must be taken into consideration.

1. Do not use very high voltage and currents for performing experiments.
2. Make sure that the wires have proper insulation and are not worn
3. Perform the experiment in a dry area and avoid spillage of water in experiment domains
4. If heating a current carrying conductor is required, submerge the conductor in oil and then heat the oil. The setup is called oil bath. Do not expose the components directly to flame.
5. Turn off the circuit when not is use to avoid overheating
6. Assemble the circuit when the switch is open to avoid electrocution and sparking

Determining the resistance of wire

Experiments are performed to determine the resistance of a wire.

1. Setup the apparatus with the battery, ammeter and the resistor in series.
2. Attach the Voltmeter in parallel with the resistor.
3. Note the readings on the ammeter and voltmeter with the switch closed.
4. Use the formula R=V/I to calculate the resistance.
5. Don’t use large current else the resistor would heat up and its resistance would increase.

6. Open the circuit when not in use to avoid overheating of components.
7. Repeat the same experiment with different batteries and calculate the resistance. Take the average of the resistances obtained.
8. For greater accuracy, plot a graph of Voltage (y-axis) against Current (x-axis) can determine the gradient.

Magnetism

Magnets: Materials that possess the property of attraction with other magnetic metals.

Non-Magnetic material: Copper, Aluminum, Silver

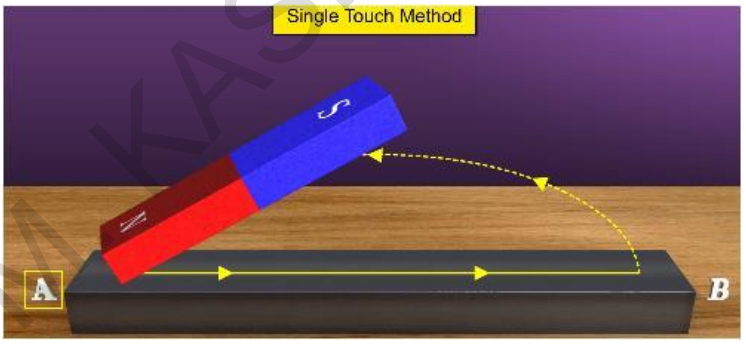
Magnetic material: Cobalt, nickel, iron, steel

Hard Magnetic material: Materials that are difficult to magnetize and difficult to demagnetize are regarded as hard magnetic material. Such material retain their magnetism when the magnetizing source is removed. Example is steel.

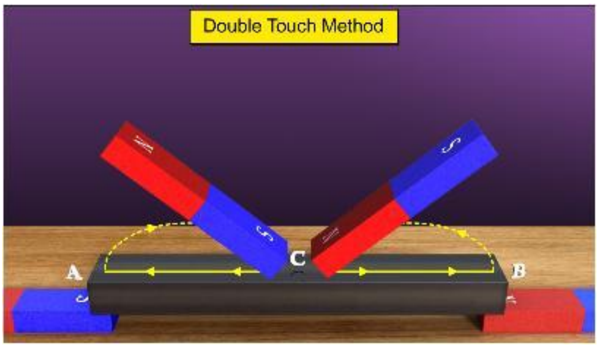
Soft Magnetic Material: Materials that are easy to magnetize and easy to demagnetize are regarded as soft magnetic material. Such material immediately get magnetized when the magnetizing source is bought near and frequently lose their magnetism when the source is removed. Example is iron and MU metal (an alloy of Nickle and Iron). Such metals are used in DC motors, electromagnets and AC generators as cores.

Methods to Magnetize:

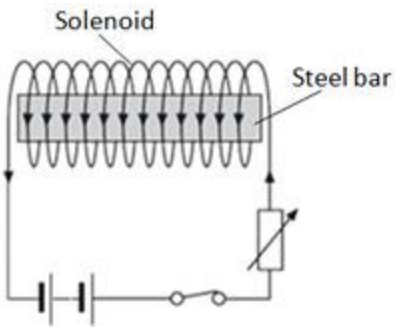
1. **Single stroke method**: Strike the metal rod with a magnet in a way that one of the magnet is used and is driven from one end of the rod to the other. After completing the first stroke, the second stroke is made using the same pole of the magnet and stroke is made in the same direction as the last stroke. When this process is repeated several times, the rod becomes a magnet. The end at which the stroke ended gains the same polarity as that of the rubbing pole and the other end gets the opposite of that pole.

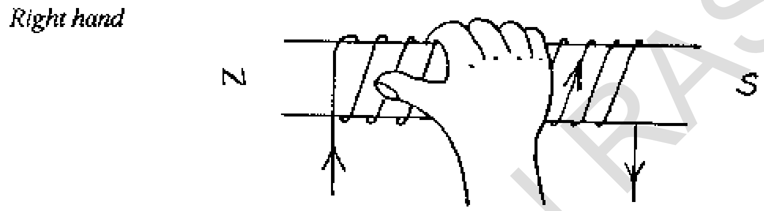


2. Double Stroke Method: This method involves two magnets. The rod is struck using both the magnets on both sides of the rod using opposite poles. The stroking is done in the similar way as in a single stroke method but this time using two magnets rather than one. The poles produced at the ends are of the opposite polarity as that of the rubbing pole.



3. **Using a DC solenoid**: The metal rod or bar is placed inside a DC solenoid as the current in passed through the coil for some time. Passage of current through the solenoid produces a magnetic field around it that is used to induce the magnetism in the bar or rod placed inside the solenoid. The rod is slowly removed from the bar from one end with the current switched on. Using the right hand grip rule, the position of the North Pole can be determined as shown.



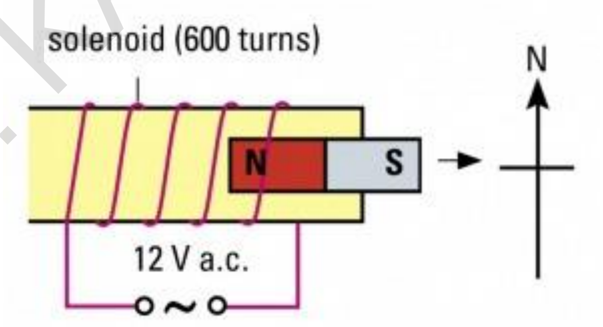


Methods to Demagnetize:

1. **Heating** the magnet makes it lose its magnetism.

2. **Striking it using a hammer** or dropping it from a certain height also destroys the magnetic tendency of the magnet.

3. **Placing the magnet in the AC solenoid** is another method. The constantly fluctuating magnetic field ruins the previously established magnetic field. The rod is then slowly removed out of the solenoid with the switch closed.



Checking the Polarity of a magnet

1. Place a compass near one of the poles of the magnet.
2. The head of the compass needle is itself a North Pole, hence it will be repelled by the North and attracted towards the South Pole.
3. If the pole repels the needle, the pole will be North Pole.
4. If the pole attracts the needle, the pole will be South Pole.

Plotting a magnetic field with a compass

1. Place the magnet at the center of a paper
2. Place a small plotting compass near the North Pole of the magnet
3. Mark a point in front of the compass where arrow head of the compass is pointing

4. Replace the compass at the mark, and mark another point where the compass now points
5. Repeat the same procedure till the compass reaches the South Pole
6. Repeat the above steps at different points to form multiple field lines

Precautions for the experiment of plotting a magnetic field

1. Make sure no strong magnetic field exists in the nearby region
2. Use small sized compass to generate multiple points for a fine magnetic field
3. Prevent the magnet from dropping as it weakens the magnetic field strength
4. Make sure the needle of the compass is freely moving
5. Place the magnet with its North aligned with the geographic North. If this is not the case, the compass would point in appropriate directions.

Method to check a strong and weak magnet

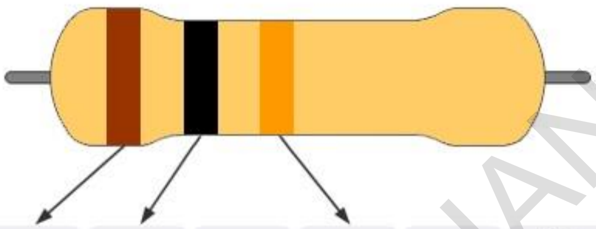
1. Expose both magnets to iron paper clips. The one that picks up the greatest number of clips is the stronger one.
2. Attach the magnet to a newton meter and lift a fixed iron plate using the setup. The magnet that requires greater force to be lifted will be the stronger magnet.

Electronics

Resistors

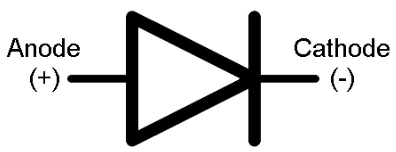
Resistors are electronic components that are used to control the current in the circuit. Resistors are marked with color bands that show the resistance of the resistor.

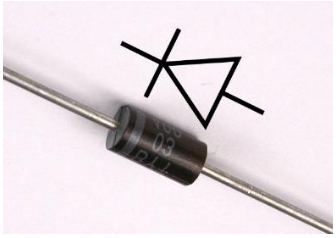
1. The first band represents the first digit of the resistor's value.
2. The second band represents the second digit of the resistor's value.
3. The third band represents the number of zeros at the end of the value.

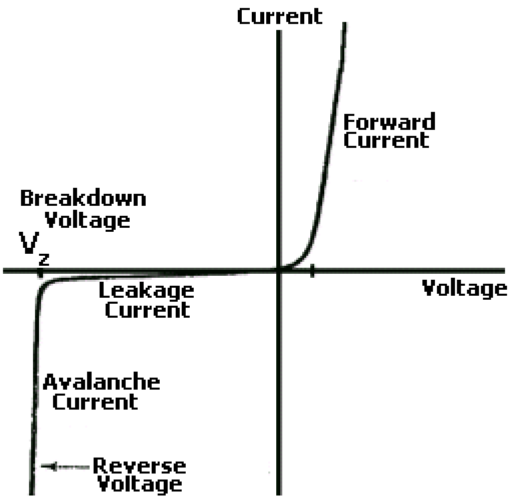


	1^{st} digit	2^{nd} digit	3^{rd} digit	multiply	tolerance	TCR (ppm/K)
Black	0	0	0	1	1% (F)	100
Brown	1	1	1	10	2% (G)	50
Red	2	2	2	100		15
Orange	3	3	3	1K		25
Yellow	4	4	4	10K		
Green	5	5	5	100K	0.5% (D)	
Blue	6	6	6	1M	0.25% (C)	10
Violet	7	7	7	10M	0.1% (B)	5
Gray	8	8	8	100M	0.05% (A)	
White	9	9	9	1G		
Gold				0.1	5% (J)	
Silver				0.01	10% (K)	
None					20% (M)	

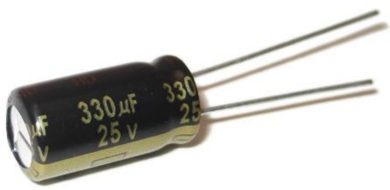
Diode: An electronic component that works to restrict the flow of current in one direction. When the diode is forward biased i.e. positive terminal of the battery is connected to positive terminal of the diode, the current is allowed to flow through the diode and hence through the circuit. But when the diode is reversed biased i.e. positive terminal of the battery is connected to negative terminal of the battery, the flow of current is restricted and the circuit is broken. Combination of diodes act as rectifiers as well. A rectifier circuit is used to convert an AC current into a DC.

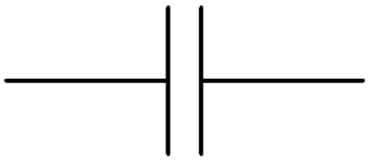






Capacitor: An electronic device that is used to store charge and supply it when there is drop of current or potential across the resistor. It is always connected parallel to the resistor. If connected in series, the circuit won't work till the capacitor is charged. Its SI unit is Farad (F). If a capacitor is connected in series, the circuit will not operate while the capacitor in charging as the charges are stored in it when it is charging.





Past Paper Questions

1. Fig. 2.1 is a circuit containing a 1.5 V cell, a switch and a lamp labelled 1.5 V, 0.20 A.

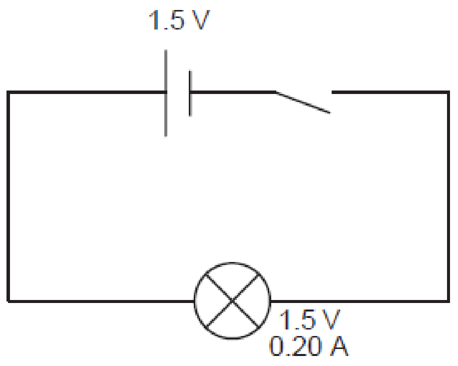


Fig. 2.1

(a) When the switch is closed the lamp does not light up.

Explain, with the aid of a diagram, how to use a voltmeter to find out whether the cell has run down.

....

.... [2]

(b) Suggest three other possible faults in the circuit that might prevent the lamp from lighting.

1. ....

.... [1]

2. ....

.... [1]

3. ....

.... [1]

2. A solar cell converts light energy into electrical energy.
A student investigates the maximum e.m.f. produced by a solar cell in the laboratory.

Fig. 4.1 shows the symbol for a solar cell.

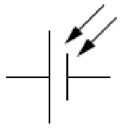


Fig. 4.1

(a) The student uses a voltmeter to measure the e.m.f. produced by the solar cell.

(i) Draw a diagram of the circuit he uses. Include a switch in the circuit.

[1]

(ii) When the student closes the switch, he notices that the voltmeter needle moves backwards, as shown in Fig. 4.2.

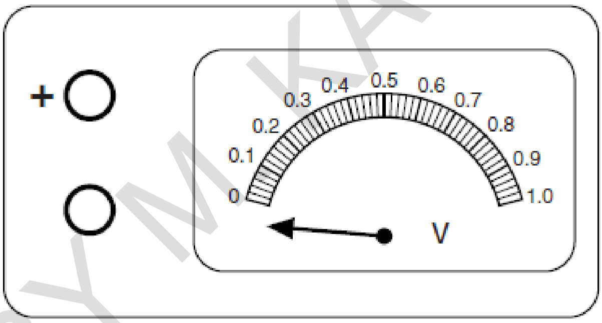


Fig. 4.2

Explain why this happens and how the student can correct this.

....

.... [2]

(iii) The student corrects the problem and, when the switch is closed, the voltmeter now reads 0.96V.
On Fig. 4.2, mark the new position of the needle. [1]

(b) To investigate the solar cell, the student uses light entering the laboratory through a window.

When the student moves his head to read the voltmeter, there is a large decrease in the reading.

Suggest a reason for this, and explain how the student can prevent this happening when he moves.

....

....

.... [2]

3. A student is asked to determine the resistance *R* of a resistor.

The student is provided with the following apparatus.

- the resistor with unknown resistance *R*
- four 1.5 V cells
- an ammeter
- a voltmeter
- connecting leads

(a) The student uses one of the 1.5 V cells in a circuit to determine the value of the resistance *R*. In the space below, draw the circuit diagram.

[2]

(b) The ammeter has one red terminal and one black terminal.
The red terminal is marked '+'.

(i) Explain why the terminals of the ammeter are different colours.

....

.... [1]

(ii) On your circuit diagram in **(a)**, label, with the letter B, the black terminal of the ammeter. [1]

(c) The student has four 1.5 V cells.

(i) In addition to 1.5 V, state three other voltages that the student could use in her circuit.

.... [1]

(ii) Draw the arrangement of cells that produces the largest voltage.

[1]

(d) The student repeats her experiment using the largest voltage.
State and explain whether this produces a different value for the resistance *R*.

....

.... [1]

4 A student investigates how a magnetic force varies with distance.

A bar magnet is attracted to the iron base of a clamp stand, as shown in Fig. 1.1.
A newton meter is attached to the magnet.

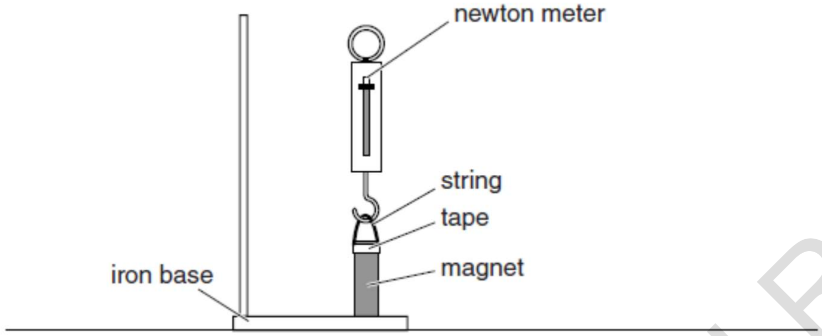


Fig. 1.1

The student pulls the newton meter vertically upwards and measures the force *F* required to pull the magnet off the iron base.

(a) **(i)** Explain why it is difficult to measure *F* accurately.

....

.... [1]

(ii) Describe a method the student can use to measure *F* more accurately.

....

.... [1]

(b) Fig. 1.2 shows the maximum reading on the newton meter as the magnet is pulled off the base.

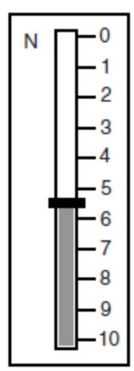


Fig. 1.2

Record the force *F* shown on the newton meter.

F = ... [1]

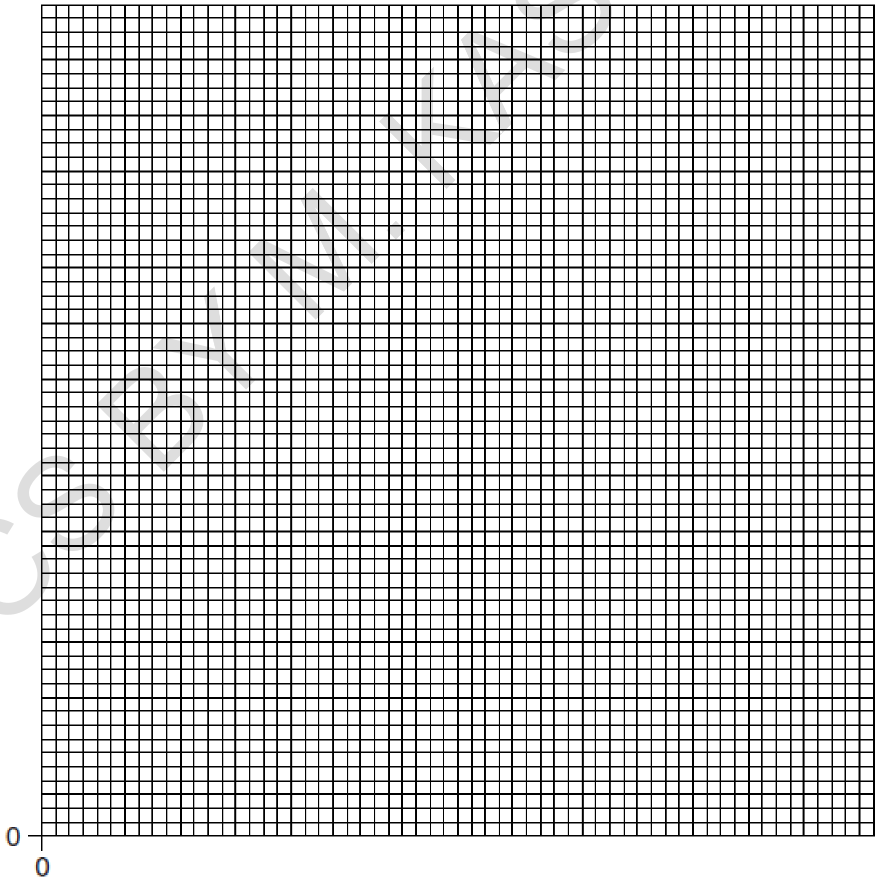
(c) The student places one sheet of paper between the magnet and the iron base and measures the force F to pull the magnet off the base.
He repeats the experiment, each time increasing the number n of sheets of paper.
The results obtained are recorded in Fig. 1.3.

n	F/N
0	
1	3.5
2	2.5
3	1.5
4	1.0
5	0.5

Fig. 1.3

On Fig. 1.3, add your value for F from **(b)**.

(i) On Fig. 1.4, plot a graph of F/N on the y-axis against n on the x-axis.
Start your axes from the origin. Draw a smooth curve of best fit.



[4]

Fig. 1.4

(ii) Describe how F varies with n.

....

.... [1]

(d) The newton meter shown in Fig. 1.2 is not suitable for measuring F when there are more than 5 sheets of paper. Suggest why.

....

.... [1]

(e) **(i)** The student repeats the experiment using paper of a different thickness. His new value of F when $n = 1$ is 3.0 N. State which paper is thicker. Give a reason for your answer.

....

.... [1]

(ii) Explain how using very thin paper improves the experiment.

....

.... [1]

(f) Very thin sheets may be made from aluminium foil.

State and explain whether aluminium foil is a suitable material for this experiment.

....

.... [1]

5. A student takes two resistors A and B from a drawer labelled 220 Ω.

The two resistors have different coloured bands, as shown in Fig. 3.1.

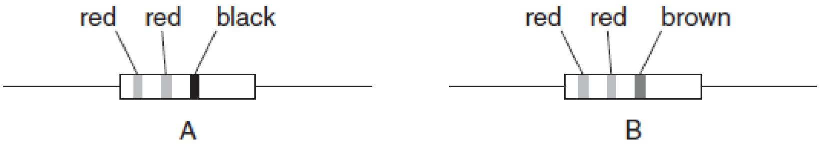


Fig. 3.1

(a) The resistor colour code is shown in Fig. 3.2.

colour band	*value*
black	0
brown	1
red	2
orange	3
yellow	4
green	5
blue	6
violet	7
grey	8
white	9

Fig. 3.2

(i) State which resistor was in the wrong drawer.

....

(ii) Use the resistor colour code to give the resistance of the resistor stated in **(i)**.

....
[1]

(b) **(i)** The student takes five more resistors from the drawer.

The student checks the resistance of each resistor, using an ammeter and a voltmeter.

In the space below, draw a circuit diagram of the circuit that he uses.

[2]

(ii) The measured resistance, in ohms, of the five resistors is

218, 220, 219, 223, 221.

The student concludes that all five resistors were in the correct drawer.

Explain why the measured resistances are not all exactly equal to 220 Ω.

....

.... [1]

For Examiner's Use

6 Two students perform an investigation into how the strength of an electromagnet depends on the number of coils of wire.

Fig. 2.1 shows the apparatus used.

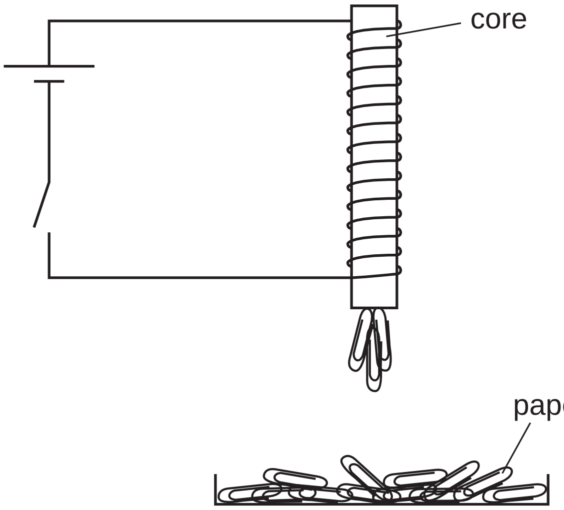


Fig. 2.1

(a) Suggest a suitable material for the core of the electromagnet.

.... [1]

(b) Outline one way of using the apparatus to estimate the strength of the electromagnet.

....

....

.... [1]

(c) The students have different plans.

Student A uses the same long piece of wire for the coils every time, and increases the number of coils by winding more of the wire round the core.

Student B cuts several wires of different lengths and uses a longer piece of wire to increase the number of coils.

State and explain which is the better plan.

....

....

.... [1]

For Examiner's Use

7 Fig. 3.1 shows a 'puzzle box' containing a single electrical component connected between the terminals A and B. The box is sealed and the component inside is hidden.

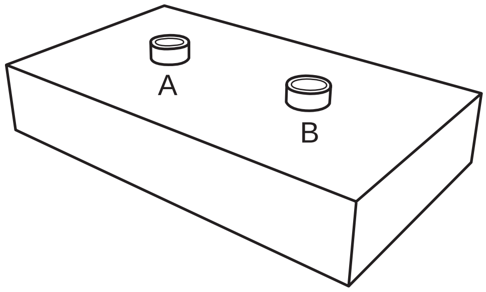


Fig. 3.1

The box contains **one** of the following:

a broken wire,
a connecting lead,
a diode,
a 20 Ω resistor.

You are to find out what is inside the box. You are provided with a 6 V battery, a lamp rated as 6 V 0.3 A and connecting leads.

(a) Draw a diagram of the circuit you would use.

[1]

For Examiner's Use

(b) Describe the procedure to be followed.

....

.... [2]

(c) State what you would expect to observe for each of the possible components in the box.

broken wire: ....

....

connecting lead: ....

....

diode: ....

....

20 Ω resistor: ....

.... [4]

For Examiner's Use

8 A student sets up a circuit to investigate how the resistance of a lamp varies with the current in it. The circuit is set up as shown in Fig. 2.1. The ammeter and voltmeter are **not** positioned correctly.

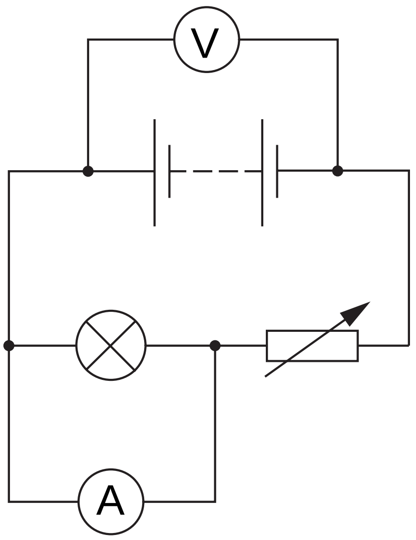


Fig. 2.1

(a) In the space above, redraw Fig. 2.1 with the ammeter and voltmeter positioned correctly. [2]

(b) In the table below, write the column headings for the readings and for the calculated values of resistance. [2]

(c) The student draws a graph of resistance against current. State and explain whether you would expect the line of this graph to pass through the origin.

....

.... [1]

For Examiner's Use

9 A diode is an electrical device that lets current pass through it in one direction only. The circuit symbol for a diode is shown in Fig. 2.1.

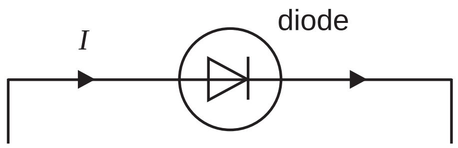


Fig. 2.1

The arrow shows the direction of the conventional current I when the diode is conducting.

(a) Complete Fig. 2.1 to show a series circuit that includes

(i) a 1.5 V power supply of fixed voltage, connected so that the diode is conducting,

(ii) an ammeter to measure the diode current I,

(iii) a switch,

(iv) a lamp, rated at 1.25 V, 0.25 A, in series with the diode and the power supply.

[3]

(b) On Fig. 2.1, mark with a '+' sign the positive terminals of the power supply and the ammeter. [1]

(c) What would happen if the diode is connected the other way round?

....

....[1]

(d) Why is it necessary to include a lamp in this circuit?

....

....[1]

Answers to Past Paper Questions

1. **(a)** diagram of cell and voltmeter (and bulb) with voltmeter across cell or bulb (1)
allow: incomplete circuit, line through voltmeter symbol
allow other components if voltmeter across cell only
ignore: switches, open or closed
NOT cell short-circuited

reading on voltmeter much less than 1.5 V (allow value if less than 1 V) (1) [2]
allow: voltmeter reads zero/no deflection on voltmeter
ignore: voltmeter would not work/check whether deflection or not/*V* across cell should be 1.5 V

(b) **any three** comments from:
mark each answer space separately, list rule applies

- bulb broken/blown
  allow: bulb fused/lamp out of order
- bulb not connected/not screwed in
- faulty switch
  allow: switch might not be closed
  ignore switch is open
- faulty connecting lead
  ignore wire missing
- detail of bad connection
- bulb rating incorrect (higher than 1.5 V) [3]
  ignore lamp needs more volts to work/voltage of cell not enough to light bulb

[Total: 5]

2. **(a)** **(i)** circuit diagram containing only solar cell, voltmeter and switch in series B1 [1]

(ii) voltmeter terminals to wrong terminals of cell
current in voltmeter in wrong direction
voltmeter has polarity B1

reverse connections to voltmeter
reverse connections to cell
connect red/+ve terminal of voltmeter to red/+ve terminal of cell B1 [2]

(iii) needle drawn from centre to 0.96 V B1 [1]

(b) (movement of) head/body reduces amount of light falling on solar cell B1
head/body not between window (light source) and cell

sensible suggestion e.g.
position of solar cell/other light sources considered B1 [2]

[Total: 6]

3. **(a)** circuit containing **one** cell and resistor, with ammeter in series B1

voltmeter in parallel with resistor / cell B1

(b) **(i)** it matters which way round it is **connected**
so you can **connect** it the right way round B1

(ii) ammeter terminal connected to –ve of cell labelled B B1

(c) **(i)** 3 (V), 4.5 (V) and 6 (V) B1

(ii) four cells drawn in series B1

(d) no change / same value **and**
resistance independent of voltage / depends only on the resistor
OR
resistance increases **and**
resistor becomes hot B1

[Total: 7]

4 **(a)** **(i)** measuring force just before it jumps
reading meter and pulling magnet at same time
force varies/not constant B1 [1]

(ii) sensible suggestion, e.g.
use of two people explained
pull slowly
repeat
video newton meter B1 [1]

(b) 5.5 ± 0.1 N unit required B1 [1]

(c) **(i)** axes: correct way round, labelled quantity and unit (on *y*-axis only) B1

scales: linear, not awkward
x-axis: e.g. 2 cm ≡ 1 *y*-axis: e.g. 2 cm ≡ 1 N B1

points plotted accurately within ½ small square
neat crosses or small points (in circle) B1

smooth curve of best fit drawn B1 [4]

(ii) increasing *n* decreases *F*
inverse relationship B1 [1]

(d) newton meter not sensitive enough
scale too big
no change/same reading
reading/force is too small (for this meter)/no force B1 [1]

(e) **(i)** new paper/second expt (thicker) as force smaller (or reverse argument)
paper that gives 3.0 N force B1 [1]

(ii) more sensitive
more readings
larger values for *F* B1 [1]

(f) **yes +** aluminium non-magnetic B1 [1]

5.

(a)	**(i)**	A	M0	
	(ii)	22 Ω cao	A1	[1]
(b)	**(i)**	circuit with resistor and d.c. power supply	M0	
		ammeter connected in series with resistor	A1	
		voltmeter connected in parallel with resistor	A1	[2]
	(ii)	tolerance / differences in manufacture / not all identical / student errors	B1	[1]
				[Total: 4]

6. **(a** iron/soft iron/mumetal **[1]**

(b) any suitable method which will give a comparison
e.g. how many/mass paper clips/pins/nails/tacks hold
distance from paper clip to make paper clip move/jump
distance from compass to make it move **[1]**

(c) A: does not change circuit/current/resistance **[1]**

[Total: 3]

7. **(a** connects battery, bulb, component in series **[1]**

(b) reverses connections in box/battery
checks brightness **[2]**

(c) no light
bright both ways
bright one way, off when connections reversed
dim both ways **[4]**

[Total: 7]

8 **(a** circuit drawn, A in series with lamp and rheostat
V in parallel with lamp **[2]**

(b) table with three columns, heading current, voltage, resistance
ignore repeats three correct units **[2]**

(c) No: filament still has resistance (when no current flows) **[1]**

Total: 5

9 **(a)** 4 items correct, 3mks; 3 items = 2mks; 2 items = 1mk. Accept historical symbols
Accept any other component provided that the function of the circuit is not compromised.
Penalise -1 (max) :- short circuit (e.g. line behind component, unless signs of use of rubber) or any compromised circuit function. B3

(b) Correct polarities, +ve signs for correct terminals of cell and ammeter (re diode). B1

(c) No current / *I* = 0, (do not accept "nothing"), accept very small "reverse" current / lamp does not light. B1

(d) One from: limit current / prevent overheating / current indicator / provides resistance B1

Total [6]

Thermal Physics

Kinetic Molecular Theory of Matter

Evaporation

The process that involves the escaping of more energetic molecules from the surface of the liquid.

Several factors affect the rate of evaporation which include

1. Surface area: Increasing the surface area increases the rate of evaporation
2. Temperature: Increasing the temperature increases the rate of evaporation.
3. Wind: Presence of wind increases the rate of evaporation
4. Humidity: Presence of moisture in the atmosphere also increases the rate of evaporation. This means higher the humidity, higher would be the rate of evaporation.
5. Atmospheric Pressure: Decreasing the atmospheric pressure increases the rate of evaporation
6. Nature of liquid: Volatile liquids have a higher rate of evaporation.

Experiments may include the study of one of the above mentioned factors on the rate of evaporation. Surface area, temperature and wind is more likely to be assessed based on the ease of experimentation.

In the case of surface area, different sized containers can be used to determine the variation in the rate of evaporation for each container.

The loss in mass of liquid (due to the evaporation) is studied over time for a specific container and the gradient of the loss in mass (y-axis) against time (x-axis) graph tells the rate of evaporation. The temperature of water and wind velocity must be kept constant.

A graph of surface area against mass of liquid lost can also be plotted for a specific time interval to determine the variation in the rate of evaporation. For example, an experiment could be conducted to measure the mass of water lost in an hour for containers of various surface area.

Thermometer

Range

The minimum and the maximum temperature that a thermometer can measure is regarded as the range of the thermometer.

Range can be increased by

1. Increasing the diameter of bore of the capillary tube
2. Increasing the length of the capillary tube
3. Decreasing the volume of mercury in the bulb. (Change in volume is directly proportional to volume.

Increasing the range of the thermometer will increase the length of it and make it difficult to handle. However, large temperature readings can be taken.

Sensitivity

The change in property per degree change in temperature is regarded as sensitivity.

Sensitivity can be increased by

1. Decreasing the diameter of the bore of the capillary tube
2. Increasing the volume of the mercury in the bulb

Increasing the sensitivity provides greater accuracy in measuring the temperature but for a limited length of capillary tube, the range will decrease. It is preferred to use more sensitive thermometers. However, range must include the temperature to be measured.

Responsiveness

The quickness of the thermometer to respond to a change in temperature is called responsiveness.

Responsiveness can be increased by

1. Using a more conductive liquid
2. Using thin walled glass bulb

Experiment can be conducted by using different thermometers of varying glass bulb thickness and the time to respond to change in temperature can be noted for determining their responsiveness. The type of liquid and the temperature difference must be kept constant throughout the experiment.

Different type of liquids in the bulb can also be used to check the responsiveness of a thermometer. Time taken to register the change in temperature can be noted using stopwatch. The thickness of the glass bulb and the temperature difference must be kept constant.

How to use a laboratory thermometer

1. While taking the reading, $1/3^{rd}$ immersion in necessary
2. Thermometer bulb should not touch the walls of the container while taking the readings of a liquid
3. Avoid parallax error while taking the reading from the thermometer by keeping the line of sight perpendicular with the markings on the thermometer

Rate of change of temperature with respect to time can be used to determine the rate of reactions as well. Gradient of the temperature time graph can be used to determine the rate of change of temperature at any point.

Modes of Heat Transfer

Conduction

The mode of heat transfer via collision between molecules. The rate of heat transfer is increased due to the existence of free mobile electrons. Hence, metals are regarded as good conductors of heat whereas non-metals are poor conductors or insulators of heat.

Experiment can be conducted by measuring the amount of wax melted when coated on a rods of different materials. The time taken for all the wax to melt can be used to determine the conductivity of the material.

The same experiment could be conducted by making containers of different material. Temperature rise in a given time interval can be noted when heated externally to measure the conductivity of the material of which the container is made of.

Convection

Convention is a combined phenomenon of conduction and advection. Advection is regarded as bulk motion of particles from one point to another.

When the liquid is heated from the bottom, it expands, becomes less dense and hence rises. The cold water which is denser, sinks to the bottom and hence a convection current is formed.

Experiments regarding convection are rarely discussed.

Radiation

The mode of heat transfer via infrared radiations is called radiation. All bodies above 0 K emit infrared radiations. Dark colored objects are good <u>emitters</u> and <u>absorbers</u> of heat than light colored objects. Similarly, shiny polished surfaces are good <u>reflectors</u> of heat than rough surfaces.

Experiments can be conducted to check the effect of different colors on the heat transfer rate. The surface area of the container, volume of liquid, type of liquid and the initial temperature of the liquid must remain constant in all experiments.

A graph of temperature rise against time can be plotted for determining the better heat absorber. The one whose temperature rises the most in the same amount of time is the best heat absorber amongst all.

A similar experiment can be conducted by varying the polish on the surface.

Heat Capacity & Melting and Boiling

Heat capacity

It is defined as the amount of heat required to raise the temperature of a substance by 1°C or 1K.

It can also be considered as the amount of energy lost when the temperature of a substance falls by 1°C or 1K.

Specific Heat Capacity

It is defined as the amount of heat required to raise the temperature of 1kg of a substance by 1°C or 1K.

Experiment can be conducted to measure the specific heat capacity of the substance. During the experiment substance should be kept insulated.

- Experimental setup to measure specific heat capacity

1 Fig. 4.1 on page 9 shows four thermometers used in a science laboratory.

(a) State the temperature reading on thermometer A. .... [1]

(b) 250 cm^3 of boiling water is poured into a beaker as shown in Fig. 4.2. The temperature is measured every 30 s for 10 minutes.

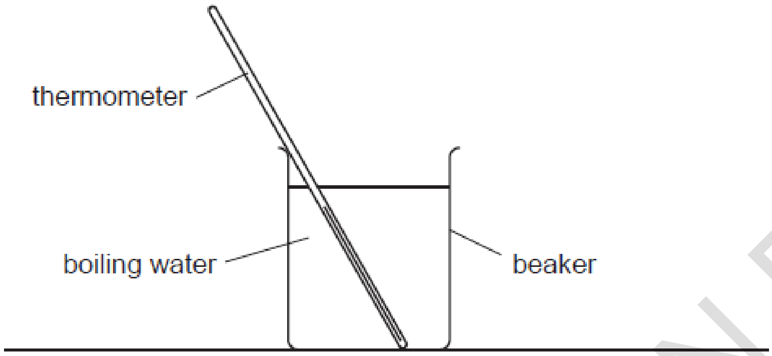


Fig. 4.2

(i) State and explain which thermometer from Fig. 4.1 is the most suitable for this experiment.

....

....

....

.... [3]

(ii) Describe how the thermometer is used in this experiment to obtain accurate readings.

....

....

.... [2]

(c) Thermometer D in Fig. 4.1 is used to measure the temperature of a person.
Fig. 4.3 shows a modern forehead thermometer. It is a thin flexible plastic strip that is placed on the forehead. The colour of the numbers changes to show the temperature.

Fig. 4.3

State one advantage of this thermometer when taking the temperature of a young child.

....

.... [1]

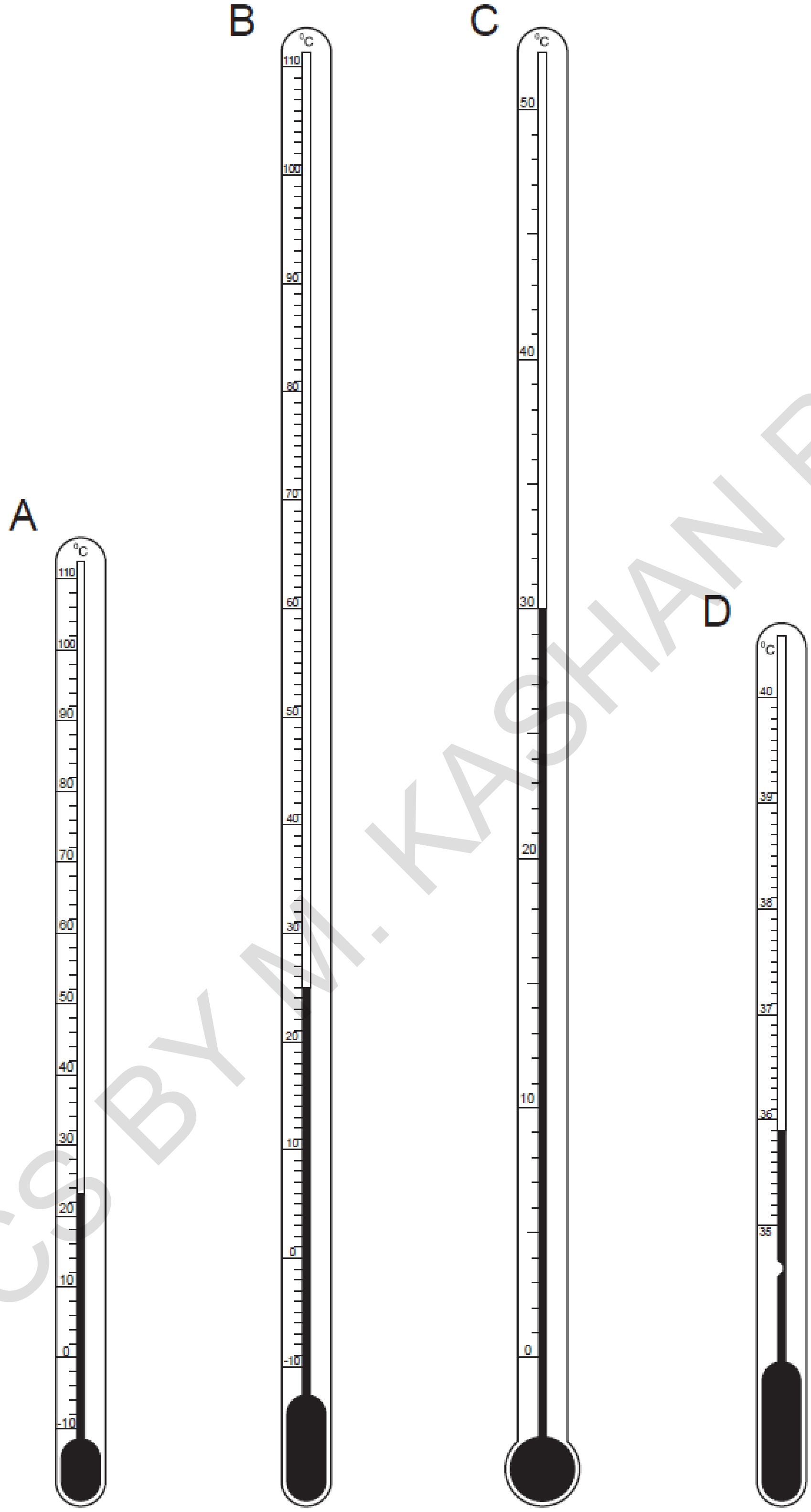


Fig. 4.1

2 Fig. 4.1 shows a block of aluminium of mass 1 kg used to measure the specific heat capacity of aluminium.

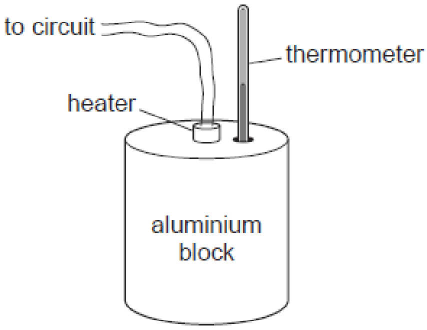


Fig. 4.1

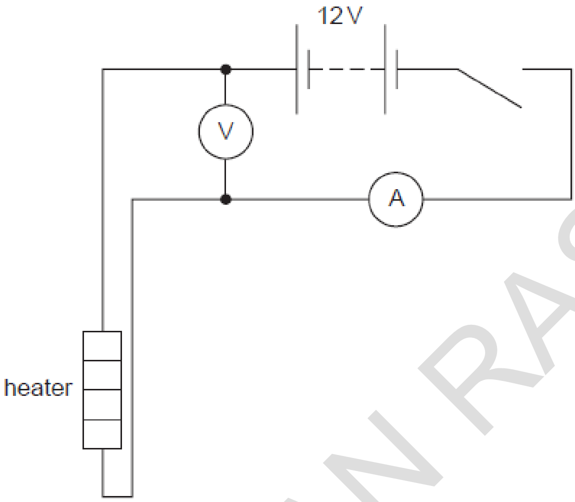


Fig. 4.2

A heater fits into a hole in the centre of the block and a thermometer fits into a second hole.

Fig. 4.2 is the circuit containing the heater.

When the switch is closed, the meters show steady readings of 11.6 V and 4.7 A.

(a) Fig. 4.3 shows the scales of the two meters.

Fig. 4.3

On Fig. 4.3, draw pointers to show the readings on the meters after the switch has been closed.

[2]

(b) When the heater is switched on, the block warms up and some heat is lost to the surroundings.

State two ways of reducing this heat loss.

1. ....

....

2. ....

.... [2]

(c) The thermometer is used to measure the initial and the final temperatures of the block.

The initial temperature of the block is taken before the heater is switched on.

Explain why the final temperature of the block is taken a short time after the heater is switched off.

....

.... [1]

(d) The heater is switched on for four minutes and the temperature rise of the block is 15 °C.

Suggest a reason why the heater is not switched on for a very much longer time.

....

.... [1]

3 The effect of surface colour on the cooling of an object is investigated.

Fig. 4.1 shows two sets of apparatus used in this investigation.

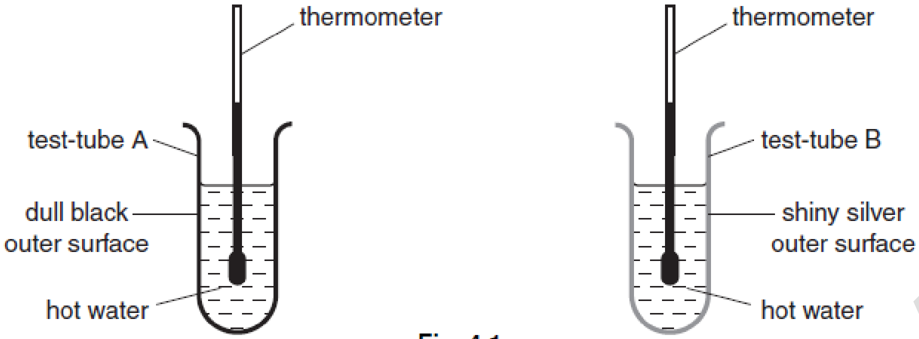


Fig. 4.1

Test-tube A has a dull black outer surface and test-tube B has a shiny silver outer surface.
The test-tubes containing hot water are allowed to cool.
Readings are taken for 20 minutes to allow cooling curves to be plotted.

(a) State two factors that must be the same for the two sets of apparatus so that the cooling curves may be compared.

1. ....

2. ....

[2]

(b) On Fig. 4.2, write the headings in the table that is to be used to record the results for test-tube A.

Fig. 4.2 [2]

(c) On Fig. 4.3, sketch and label the shape of the cooling curves for test-tube A and for test-tube B.

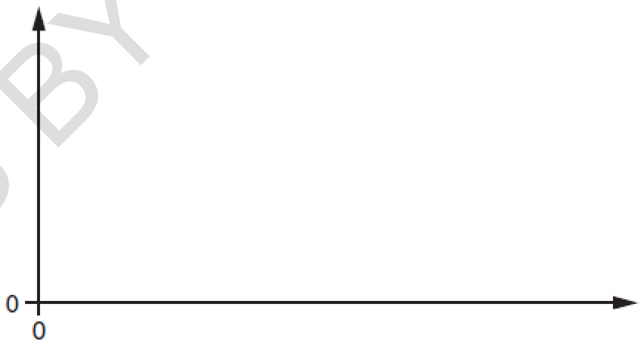


Fig. 4.3 [2]

4 A student compares the conduction of heat through different metals.
Fig. 3.1 shows the apparatus used.

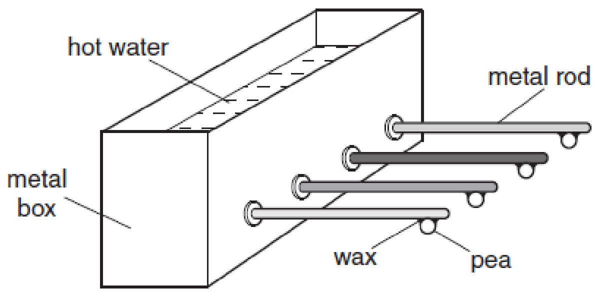


Fig. 3.1

Four rods of different metals each have one end fixed through a cork into a metal box. The metal box contains hot water. Each rod has a pea attached to it by wax.

(a) Heat from the hot water is conducted to the end of each rod.
Describe what happens to the wax and to the pea on one of the rods.

....

....

.... [1]

(b) State two factors that should be the same for all the rods in this experiment.

1. ....

2. ....

[2]

(c) State how the experiment shows which of the metals is the best conductor of heat.

....

.... [1]

(d) The student is asked to suggest an improvement to the experiment.
He suggests placing several peas along each rod, as shown in Fig. 3.2.

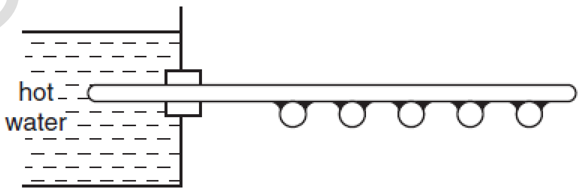


Fig. 3.2

Explain how this gives a better comparison of the conduction of heat through the different metals.

....

....

.... [1]

5 A laboratory thermometer is used to measure the temperature of oil in a test-tube. The thermometer is initially at room temperature.

Fig. 3.1 shows the thermometer.

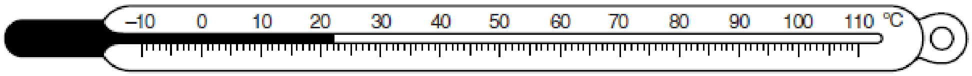


Fig. 3.1

(a) State the temperature shown by the thermometer in Fig. 3.1.

temperature = ... [1]

(b) A test-tube of oil is heated in a bath of very hot water for 15 minutes, as shown in Fig. 3.2.

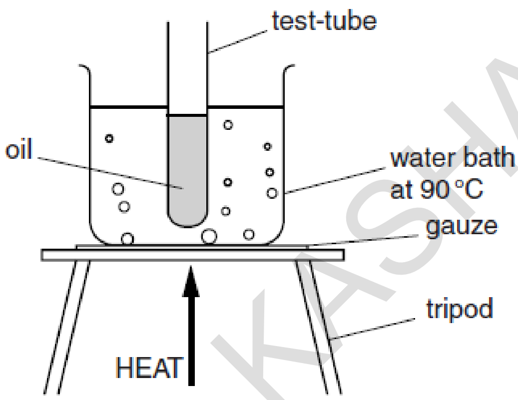


Fig. 3.2

(i) Explain why the level of oil in the test-tube should be below the level of water in the water bath.

....

....[1]

(ii) A student removes the test-tube from the water bath. He then places the thermometer in the oil. Describe how the reading on the thermometer changes over the next few minutes.

....

....

....[2]

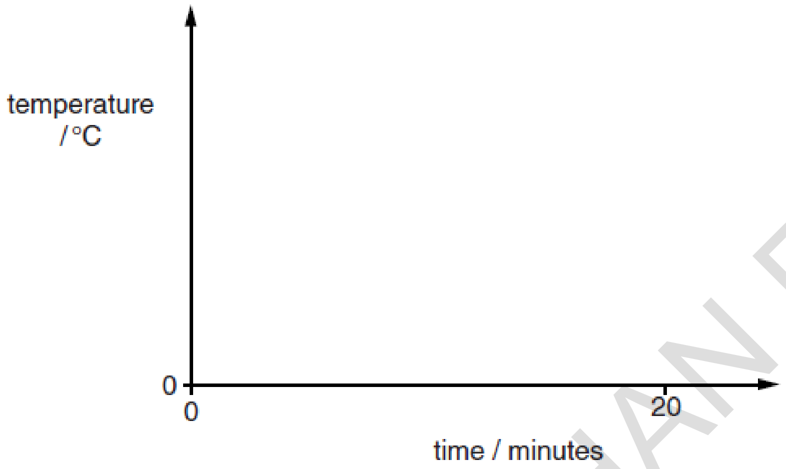
(iii) Describe how the student reads the thermometer accurately.

....

....[1]

(c) A second student repeats the experiment in **(b)** using a temperature sensor instead of a thermometer. The temperature sensor is connected to a data logger. The data logger records the temperature every 0.1 s for 20 minutes.

On the axes shown in Fig. 3.3, sketch the shape of the graph produced by the data logger.



[2]

Fig. 3.3

7 A student plots a heating curve for water.

The student places an electrical heater in a beaker of water at room temperature, as shown in Fig. 2.1.

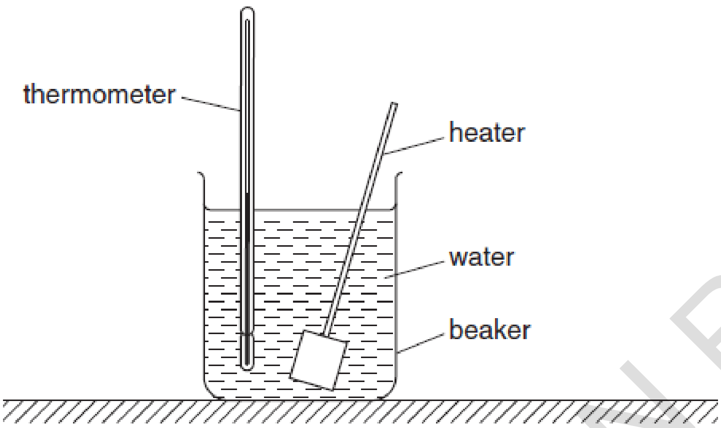


Fig. 2.1

The student measures the temperature of the water every minute for thirty minutes.

(a) The student suggests using the second hand of a wall clock to measure the time. Another student suggests using a stopwatch reading to 0.01 s. Suggest and explain which timer is the more suitable to use.

....

....[1]

(b) The student draws a table to record the results.

On Fig. 2.2, complete the headings of the table.

Fig. 2.2

[2]

(c) The student starts with water at room temperature and notices that the temperature increases for 20 minutes and then stays steady at 60 °C.

(i) The student uses the data to plot a graph of the variation with time of the temperature of the water. On the axes of Fig. 2.3, sketch the shape of the graph obtained. Mark any known values on the graph.

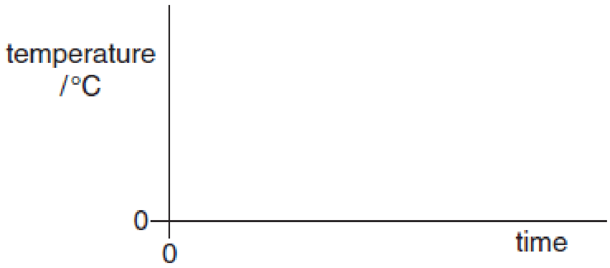


Fig. 2.3

[3]

(ii) Explain why the temperature of the water does not rise above 60°C.

....

....[1]

4	(a)	wax melts and pea falls off	B1	[1]
	(b)	Any TWO from: thickness of rod length of rod/distance to pea mass of wax/mass of pea/length of rod in water	B2	[2]
	(c)	pea falls off first	B1	[1]
	(d)	credit sensible suggestion, e.g. peas closer to heat, falls off more quickly/quicker results can time peas falling off can plot graph (distance against time)	B1	[1]
				[Total: 5]
5	(a)	22(.0)°C unit required	B1	[1]
	(b) (i)	all the oil is heated/ all oil below water surface/ uniform heating of oil	B1	[1]
	(ii)	temperature rises then falls	B1 B1	[2]
	(iii)	avoid parallax error/good explanation reads top of meniscus aligns scale with liquid column	B1	[1]
	(c)	smooth concave curve asymptotes to above zero	B1 B1	[2]
				[Total: 7]
7	(a)	wall clock + only need to measure to nearest second / accurate enough / time measured is large stopwatch + easier to hold / closer to apparatus ignore easier to use / read / reaction errors NOT stopwatch as it is more accurate	B1	
	(b)	quantities time or t and temperature or θ or T allow temperature change but no ecf to graph **(c)(i)** units minutes or min (NOT m or s) and °C correct (NOT K) allow T or t for either temperature or time, but not same for both	B1 B1	
	(c) (i)	shape of curve correct allow two straight lines joined by small curve NOT just two straight lines line starts from t = 0 and θ above 0 (room temp) (approx) horizontal from (approx) t = 20 min at θ = 60°C 20 min and 60°C must be labelled	B1 B1 B1	
	(ii)	heat gained from heater = heat lost to surroundings / reaches equilibrium heater not powerful enough	B1	
				[Total: 7]