FORM THREE PHYSICS TOPICAL QUESTIONS

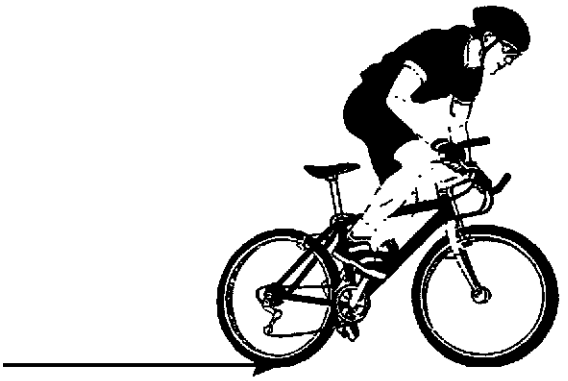
LINEAR MOTION

INSTRUCTIONS TO CANDIDATES

*Answer **ALL** questions in this paper in the spaces provided.*

1. Two forces that act on a moving cyclist are the **driving force** and the **resistive force.**

(a) The diagram shows a cyclist.



(i) Add an arrow to show the direction of the resistive force.

(1)

(ii) The cyclist is speeding up. Which is the correct statement about these two forces?

A The driving force is **greater** than the resistive force.

B The driving force is **smaller** than the resistive force.

C The driving force is the **same** as the resistive force.

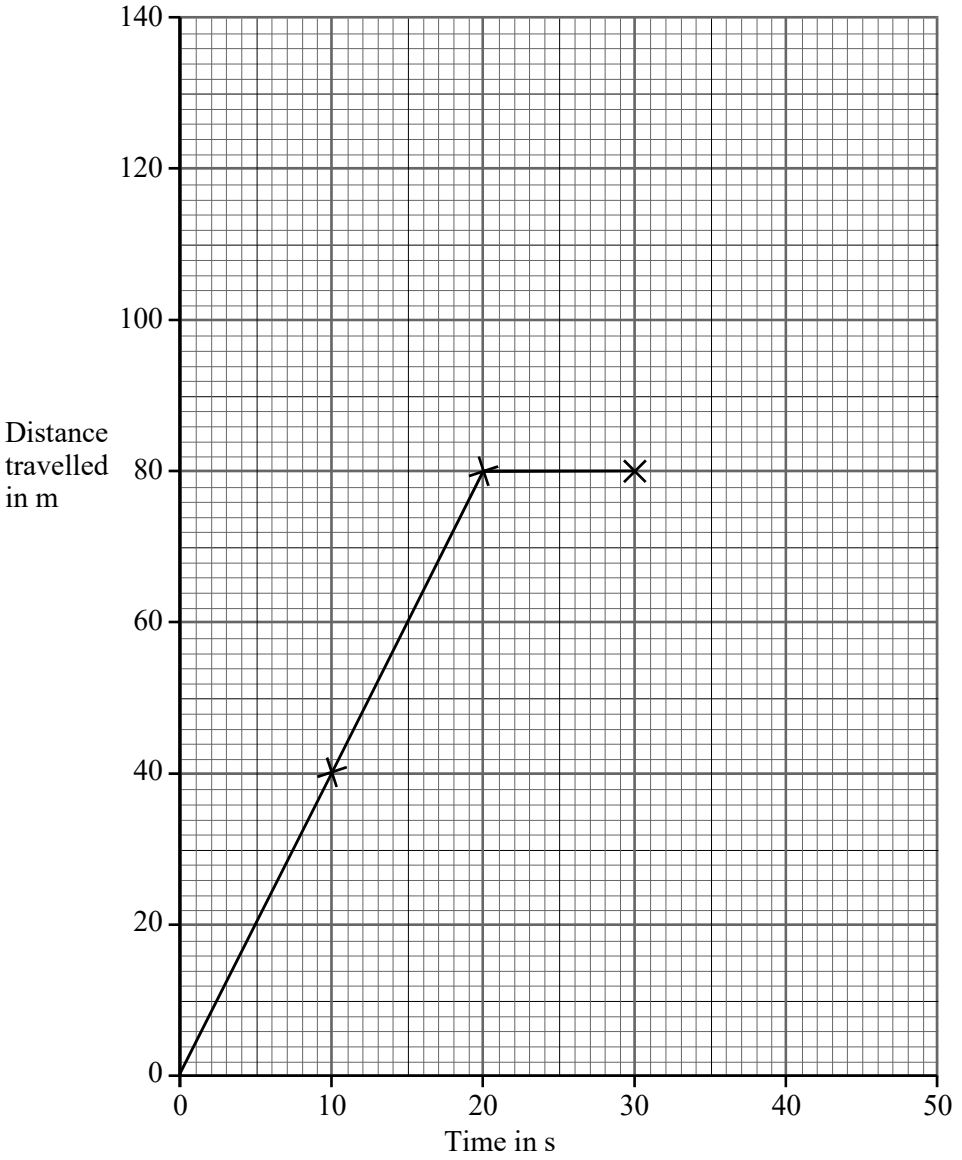
Write the correct answer (**A, B** or **C**) in the box. ☐

(1)

(b) The table shows how the distance travelled by a cyclist changes with time.

Distance travelled (m)	0	40	80	80	110	140
Time (s)	0	10	20	30	40	50

Some of these points have been plotted on the graph.



(i) Complete the graph.

(2)

(ii) Between which TWO times shown on the graph was the cyclist not moving?

Between.....s and .....s

(1)

(iii) Between which TWO times shown on the graph did the cyclist have the greatest speed?

Between.....s and .....s

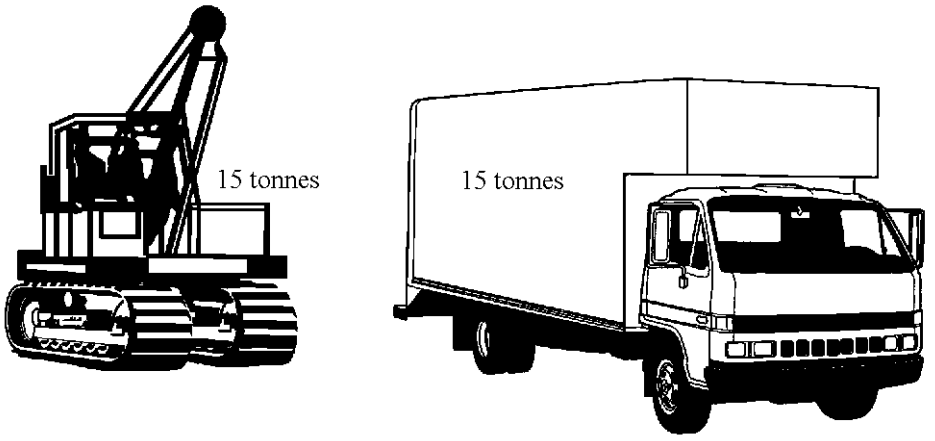
Explain your answer.

.....

.....

(2)
(Total 7 marks)

2. The diagram shows a mobile crane and a removal van. Each vehicle has a mass of 15 tonnes (15 000 kg).



The van and the crane both start to move. The table shows their speed during the first ten seconds of movement.

	Speed after 5 s	**Speed after 10 s**
Van	10 m/s	15 m/s
Crane	3 m/s	5 m/s

(a) Which vehicle has the greater acceleration? Explain how you can tell.

.....

.....

.....

(2)

(b) The driving force used by the mobile crane to make it move is 20 000 N.
Explain why the driving force used by the removal van must be greater than 20 000 N.

.....

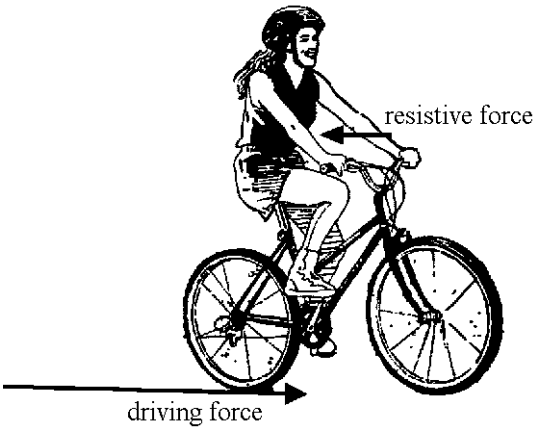
.....

.....

.....

(2)
(Total 4 marks)

3. The diagram shows the horizontal forces acting on a cyclist while she is accelerating.



(a) Explain how the unbalanced force acting on the cyclist changes as she accelerates and then cycles at a constant speed.

.....

.....

.....

.....

.....

.....

(3)

(b) Some racing cycles have lightweight frames. Why is it an advantage for the cycle to have a lightweight frame?

.....

.....

.....

.....

(2)

(c) (i) A cyclist and her cycle have a total mass of 85 kg.
Calculate the combined kinetic energy of the cyclist and cycle when travelling at a speed of 12 m/s.

.....

.....

.....

.....

.....

.....

(3)

(ii) The kinetic energy of the cyclist and cycle increases at an average rate of 180 joules per second.
Calculate the time it takes to gain this energy.

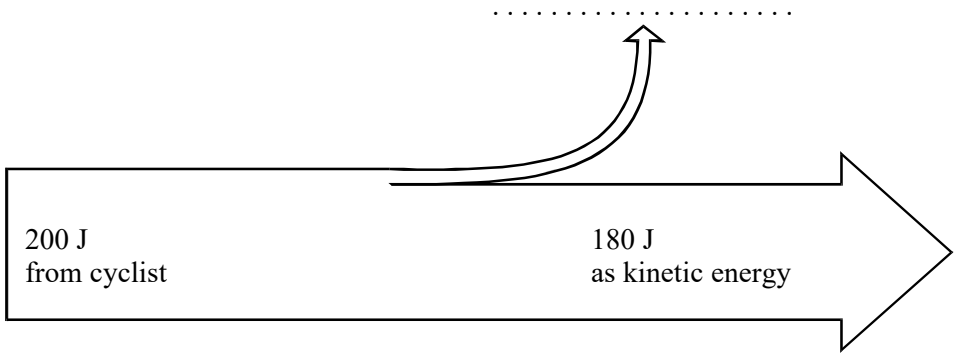
.....

.....

.....

(2)

(d) The diagram shows the energy flow through the cycle during the first second that the cyclist is accelerating.



(i) Complete the diagram by labelling the top arrow.

(1)

(ii) Calculate the efficiency of the cycle.

.....

.....

.....

(3)

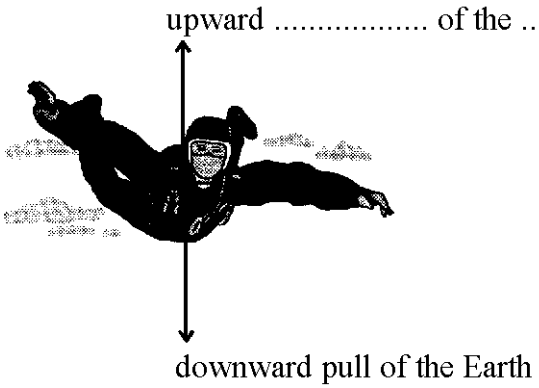
(iii) When the cyclist is travelling at constant speed, the kinetic energy is constant although the cyclist is still producing 200 J/s.
Where does the energy go?

.....

.....

(1)
(Total 15 marks)

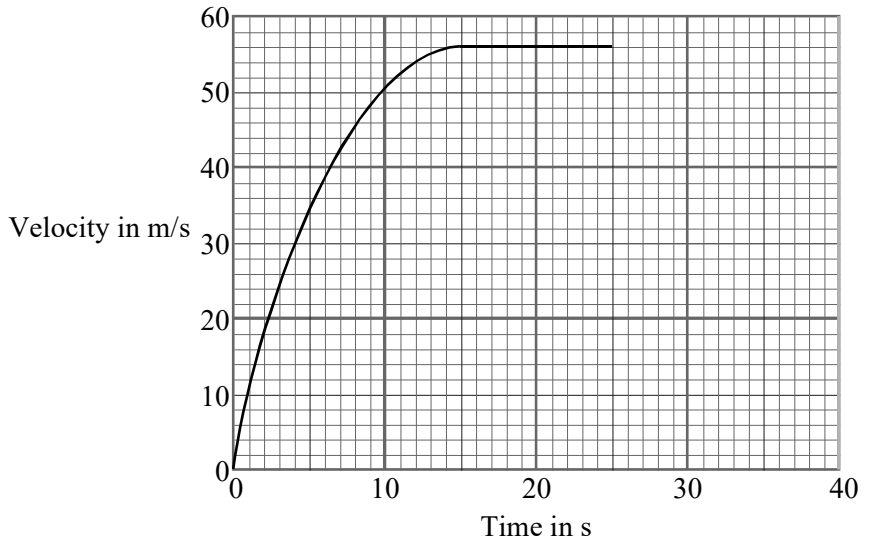
4. A skydiver jumps out of an aircraft.
The diagram shows the two forces acting on the skydiver.



(a) Complete the label on the upward arrow.

(2)

(b) The graph shows how her velocity changes before she opens her parachute.



What is the skydiver's terminal velocity?

..... m/s

(1)

(c) What is the relationship between the two forces on the skydiver,

(i) before she reaches terminal velocity;

.....

.....

(1)

(ii) when she is travelling at terminal velocity?

.....

.....

(1)

(d) The skydiver opens her parachute 25 s after leaving the aircraft.
She reaches a new terminal velocity ten seconds later.

(i) Add a line to the graph to show how her velocity changes after she opens her parachute.

(2)

(ii) Explain why her velocity changes in this way.

.....

.....

.....

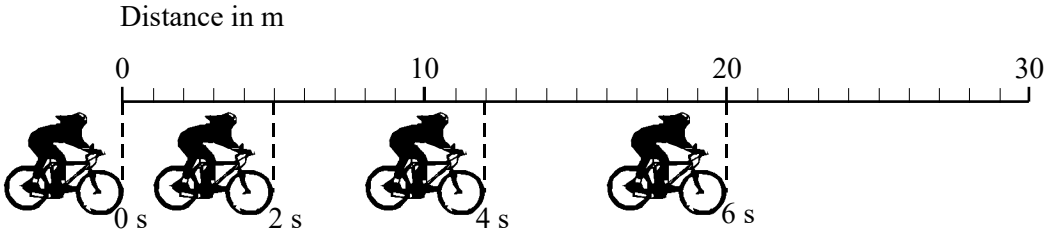
.....

.....

.....

(3)
(Total 10 marks)

5. A cyclist sets off from a standing start.
Photographs are taken of the cyclist at 2 s intervals.
The diagram shows the results.



(a) What happens to the cyclist's speed during the 6 s shown?
Explain how you can tell.

.....

.....

(2)

(b) How far does the cyclist travel in the first 4 s?

.....

(1)

(c) After 6 s the cyclist slows down.
Mark the scale with an **X** to show a possible position of the cyclist's front wheel when the next photograph is taken.

(1)
(Total 4 marks)

6. (a) (i) A book slides across a flat horizontal table and comes to rest.
What causes it to stop?

.....

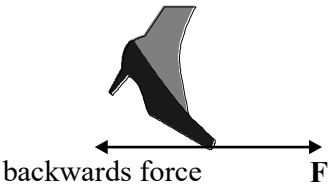
(1)

(ii) What has happened to its kinetic energy?

.....

(1)

(b) The diagram shows some of the forces acting between a shoe and the ground while walking.



Name the force **F**.

.....

(1)
(Total 3 marks)

7. When an athlete attempts to jump over a horizontal hurdle he pushes down on the ground.

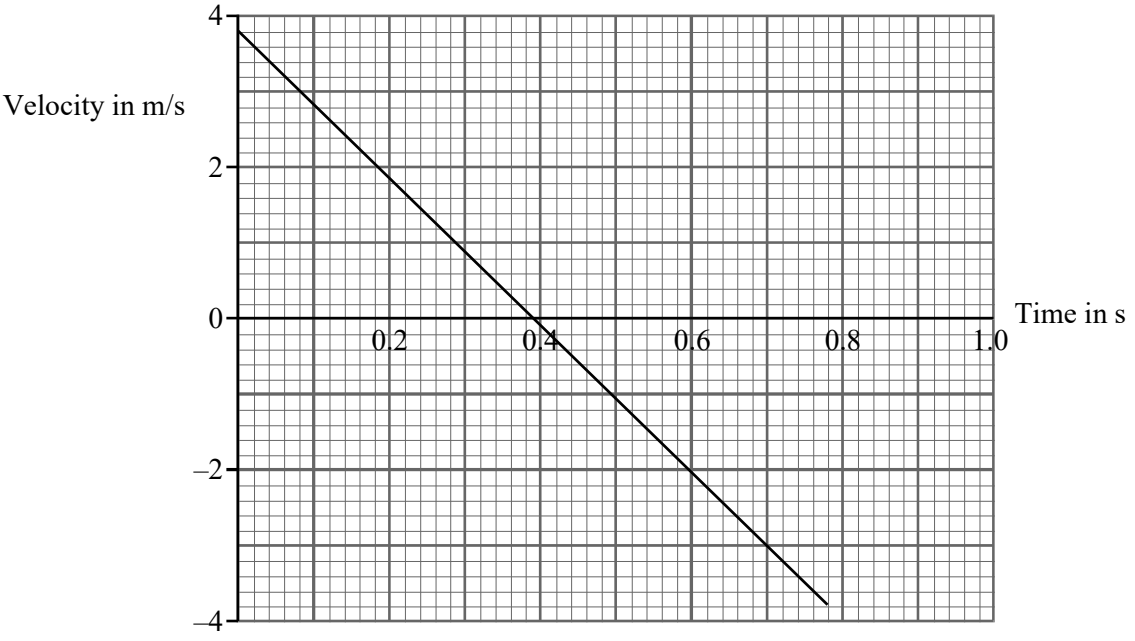
(a) Describe the force that causes the athlete to move upwards.

.....

.....

(2)

(b) The graph shows how the upwards velocity of the athlete changes after leaving the ground.



(i) After what time does the athlete reach his maximum height?

.....

(1)

(ii) What height does the athlete reach?

.....

.....

.....

(3)

(iii) Calculate the acceleration of the athlete.

.....

.....

.....

(3)

(iv) What is the direction of the acceleration?
Explain how you can tell from the graph.

.....

.....

(2)

(v) The mass of the athlete is 65 kg.
Calculate the force required to cause this acceleration.

.....

.....

.....

(3)

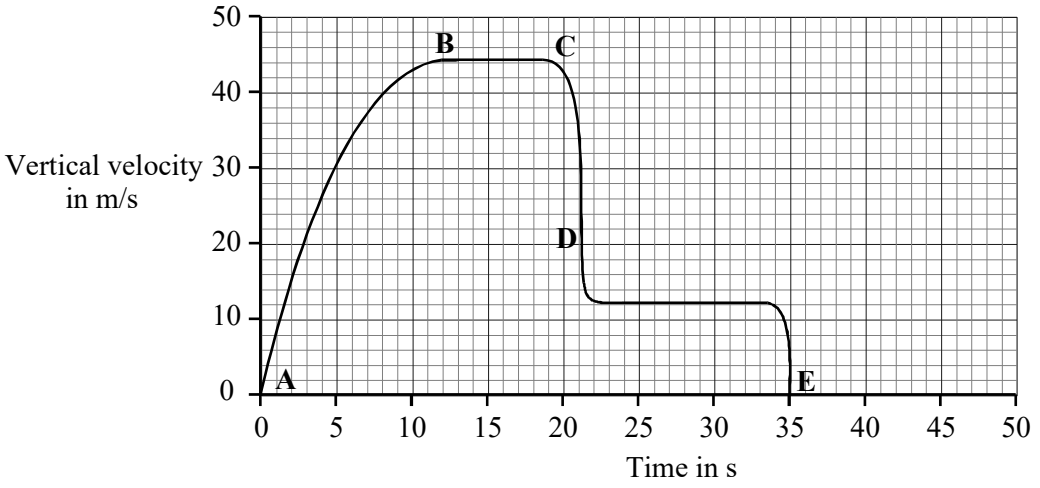
(vi) Describe the force that causes the athlete's acceleration.

.....

.....

(1)
(Total 15 marks)

8. A sky-diver of mass 70 kg jumps from a plane. The graph shows how the vertical velocity of the sky-diver varies with time. Parts of the graph have been labelled **A**, **B**, **C**, **D** and **E**.



(a) At **A**, the sky-diver has an acceleration equal to the acceleration due to gravity of 10 m/s^2. Calculate the resultant force acting on the sky-diver at this instant.

.....

.....

.....

(3)

(b) How can you tell from the graph that in the time period from **B** to **C** the resultant force acting on the sky-diver is zero?

.....

.....

.....

.....

(2)

(c) Describe and explain the motion of the sky-diver from **C** until he lands at **E**.

.....

.....

.....

.....

.....

.....

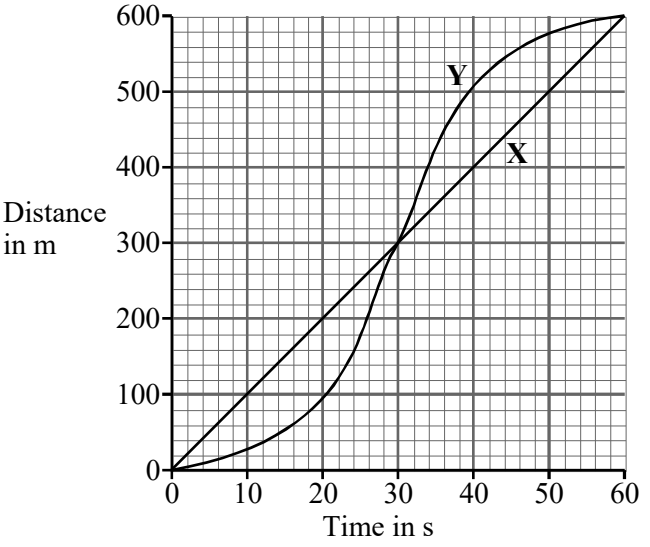
.....

(4)

(d) A sky-diver, of the same mass, falls from the same height but uses a parachute with a larger surface area. On the grid, sketch a graph to show his motion.

(2)
(Total 11 marks)

9. The graph shows how the distances travelled by two cars **X** and **Y** varies with time.



(a) State the total distance travelled by each car.

.....

(1)

(b) At 20 seconds, how much further has car **X** travelled than car **Y**?

.....

.....

(2)

(c) How do you know from the graph that car **X** travelled at a steady speed?

.....

(1)

(d) Which car is travelling at the greatest speed after 30 seconds?
State how you know.

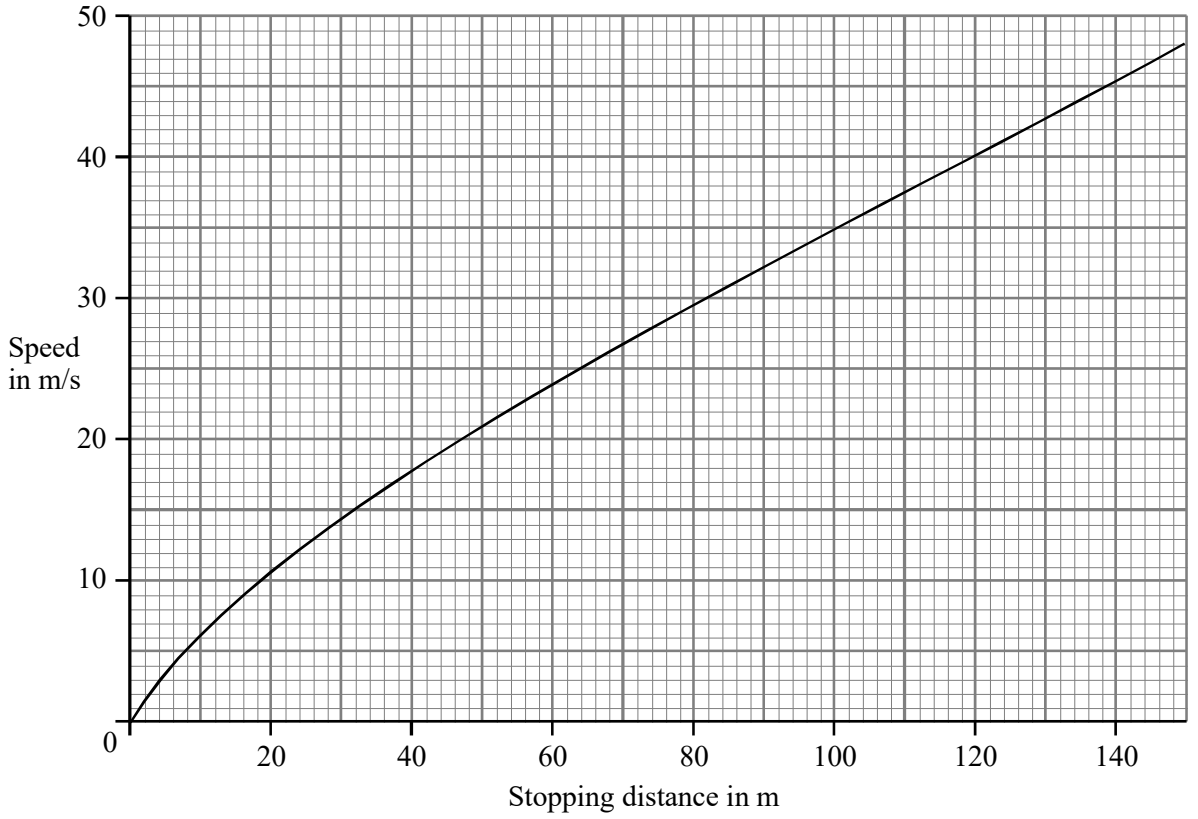
.....

.....

.....

(2)
(Total 6 marks)

10. The graph shows how the stopping distance of a car on a dry level road depends on the speed.



(a) State how the stopping distance changes with the speed of the car.

.....

.....

(1)

(b) Use the graph to estimate the stopping distance for a speed of 45 m/s.

.....

.....

(1)

(c) When the weather conditions are poor, the stopping distances change.

Add another line to the graph to show how the stopping distance may vary with speed if the road conditions are very wet.

(2)

(d) Describe the energy changes taking place as the car is brought to a stop by the brakes.

.....

.....

(2)

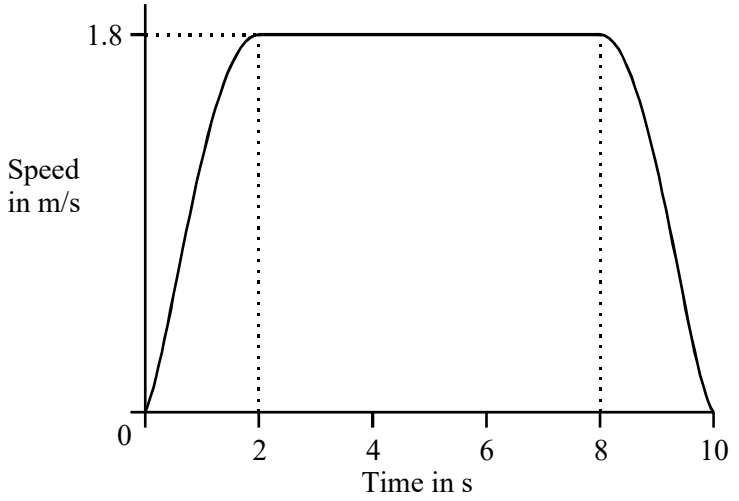
(e) Explain why the stopping distance of a car travelling uphill is less than when it is travelling on a level road.

.....

.....

(1)
(Total 7 marks)

11. The graph shows how the speed of a lift changes with time as it **descends** from the third to the ground floor of a building.



Use the graph to answer the following questions.

(a) Between which times is the lift increasing in speed?

.....

(1)

(b) What is the direction of the resultant force on the lift between 8 and 10 seconds? Explain your answer.

.....

.....

.....

(2)

(c) Estimate the height of the third floor above the ground floor.
Show clearly how you arrived at your answer.

.....

.....

.....

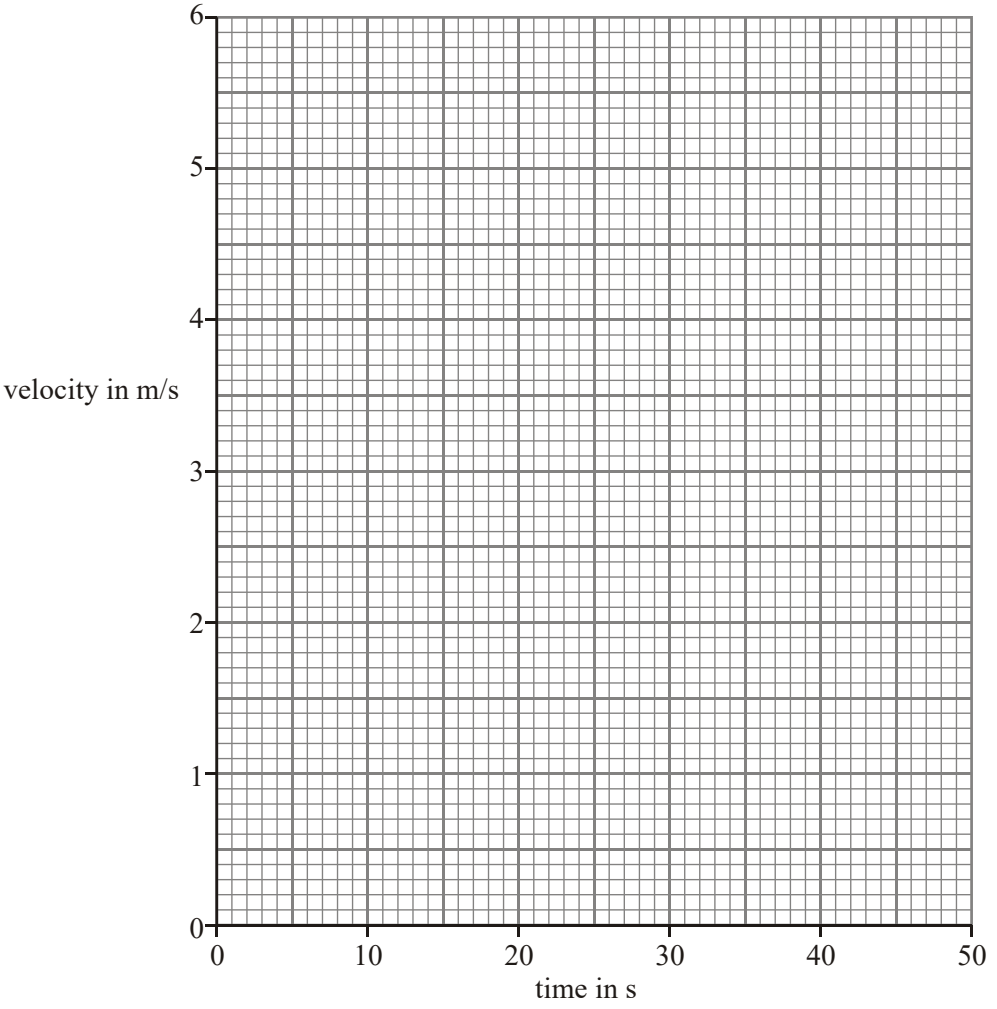
(3)
(Total 6 marks)

12. A train accelerates from rest along a straight track.

The table shows how the train's velocity changes with time.

time (s)	0	10	20	25	30	40
velocity (m/s)	0	2	4	4.5	5	5

(a) Use the grid to draw a graph of velocity against time.



(2)

(b) What is the train's velocity at 15 s?

.....

(1)

(c) (i) State the equation for acceleration in terms of velocity and time.

.....

(1)

(ii) Calculate the acceleration of the train in the first 15 s.

.....

.....

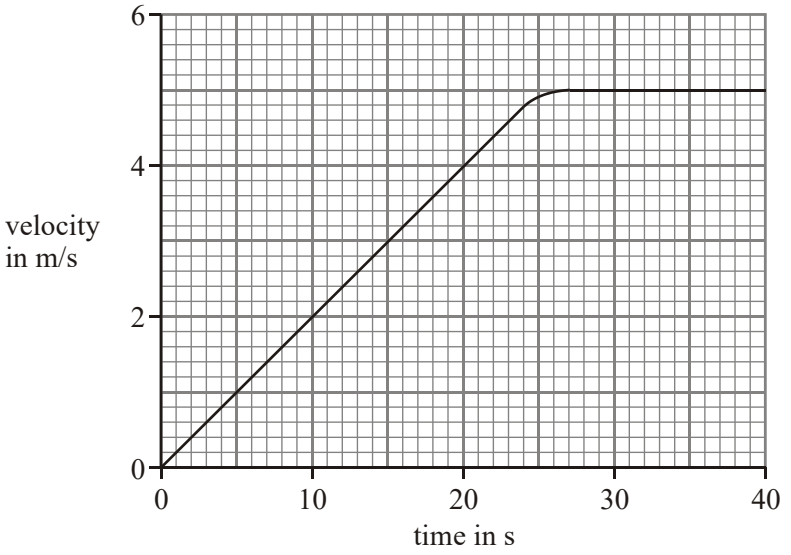
.....

(2)

(Total 6 marks)

13. A train accelerates from rest along a straight track.

The graph shows how the train's velocity changes with time.



(a) (i) How can the distance travelled be determined from a velocity-time graph?

.....

(1)

(ii) Calculate the distance travelled by the train in the first 15 s.

.....

.....

(2)

(b) The mass of the train is 120 000 kg.

Calculate the unbalanced force on the train at 10 s.

.....

.....

.....

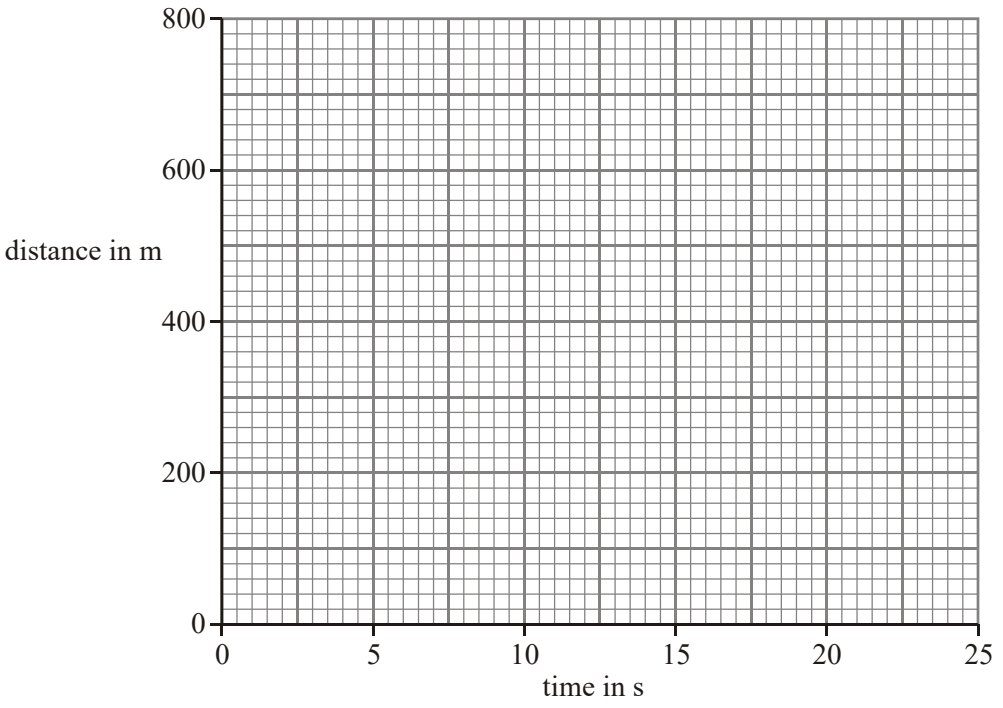
.....

(4)
(Total 7 marks)

14. The table shows how the distance travelled by a train on a straight section of track varies with time.

distance (m)	0	150	300	450	600	750
time (s)	0	5	10	15	20	25

(a) Use the grid to plot a graph of distance against time.



(2)

(b) How can you tell from the graph that the train was travelling at a constant speed?

.....

.....

(1)

(c) Use the graph to calculate the speed of the train on this section of the track.

.....

.....

.....

(3)

(d) A constant driving force acts on the train throughout this section of track.

Explain why the speed of the train does not increase.

.....

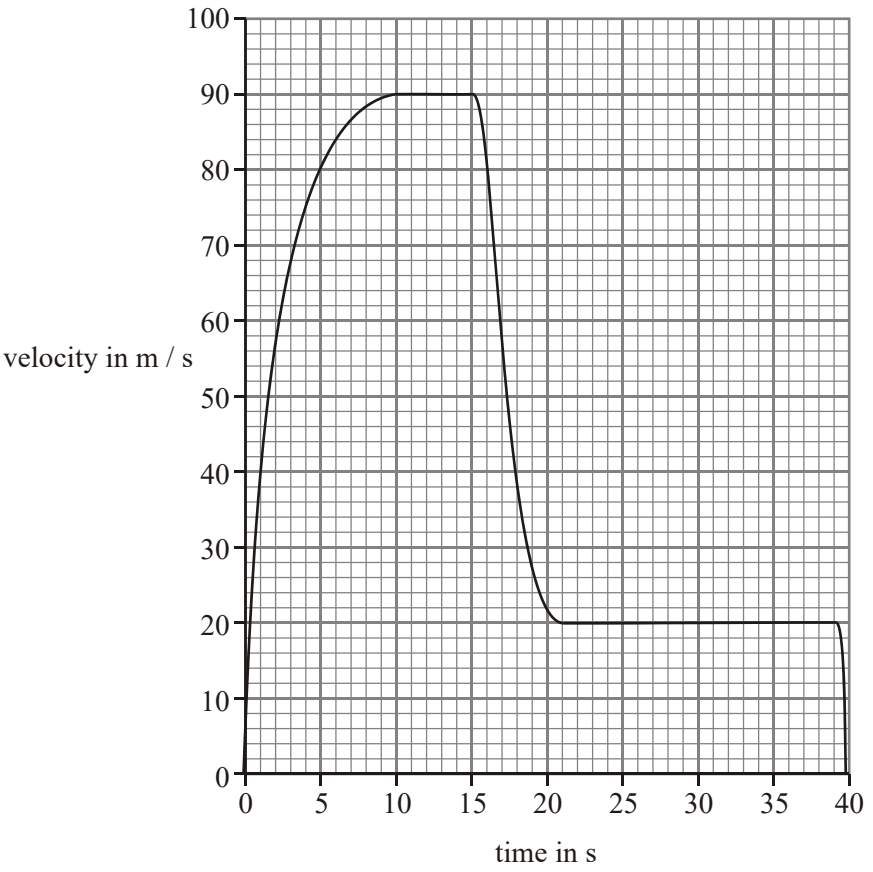
.....

.....

(2)

(Total 8 marks)

15. (a) The graph shows how the downward velocity of a parachutist changes with time from leaving the aircraft to landing on the ground. The parachute is not opened until some time into the fall.



Use the graph to answer the following questions.

(i) What was the maximum velocity of the parachutist?

..... m/s

(1)

(ii) For how long did the parachutist fall after leaving the aircraft?

..... s

(1)

(iii) At what time did the parachutist open the parachute?

Explain your answer.

.....

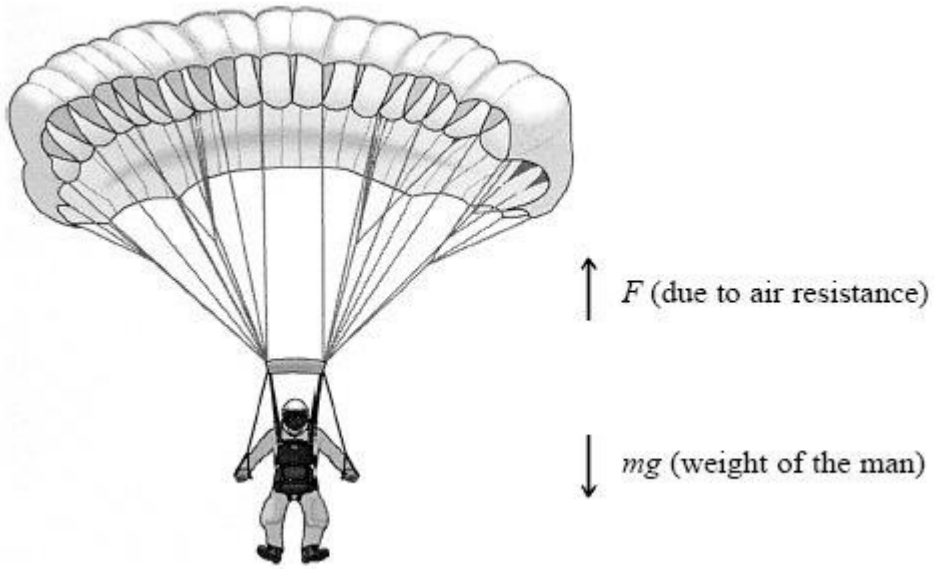
.....

(2)

(iv) What was the terminal velocity at which the parachutist fell while the parachute was open?

..... m/s

(b) The diagram shows the forces acting on the parachutist once the parachute has been opened.



Between 16 and 21 seconds the parachutist's velocity changes.

Describe the way in which the forces acting on the parachutist change during this time.

Your answer should refer to the two forces shown in the diagram.

.....

.....

.....

.....

(3)

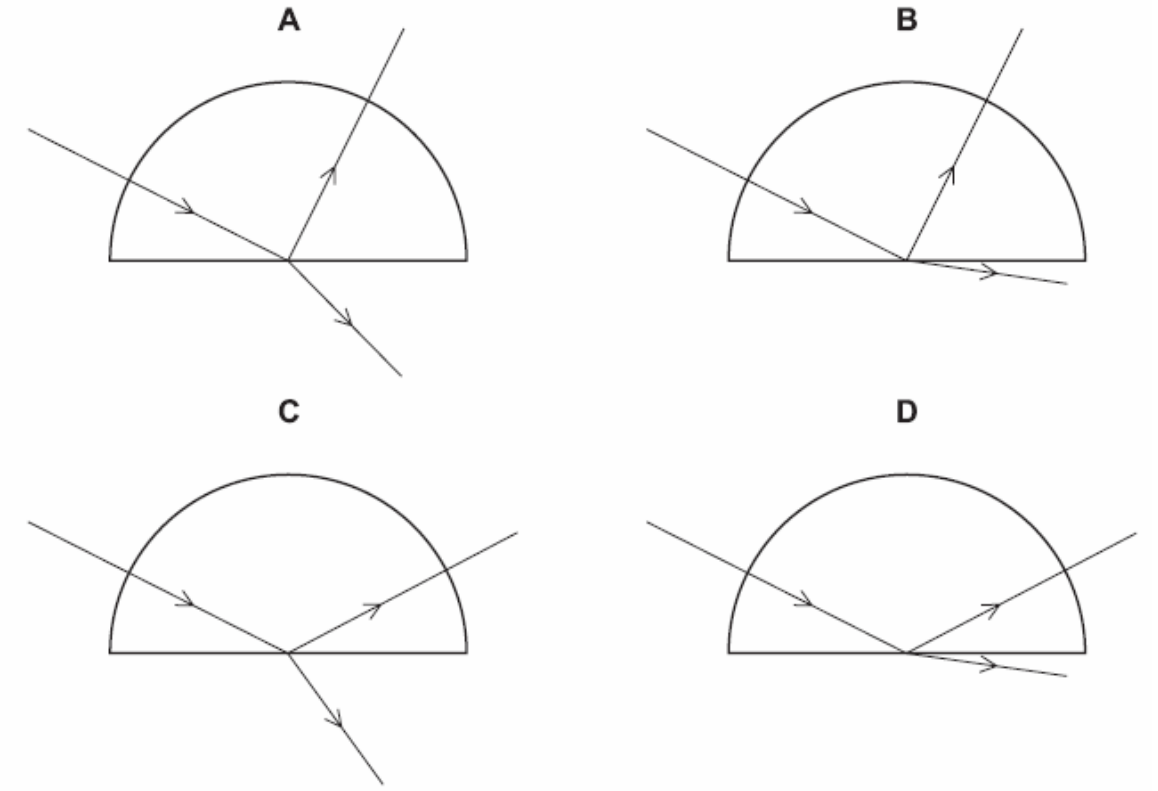
(Total 8 marks)

NAME: .....

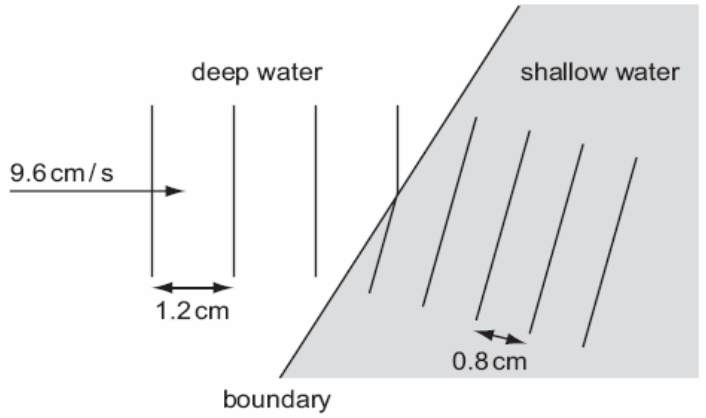
REFRACTION

1. A ray of red light enters a semi-circular glass block normal to the curved surface.

Which diagram correctly shows the partial reflection and refraction of the ray?



2. A ripple tank is used to demonstrate refraction of plane water waves.



Waves in deep water have a wavelength of 1.2 cm and a speed of 9.6 cm / s. The wavelength of the waves in shallow water is 0.8 cm.

What is the speed of the waves in the shallow water?

A 6.4 cm / s

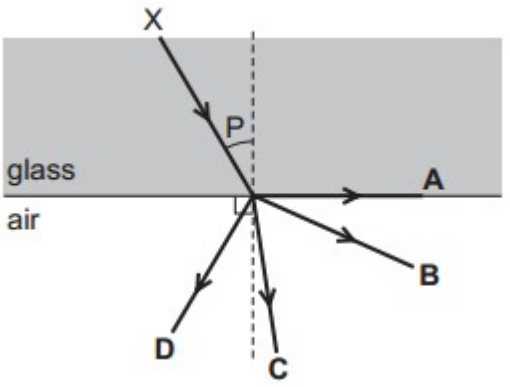
B 8.0 cm / s

C 9.6 cm / s

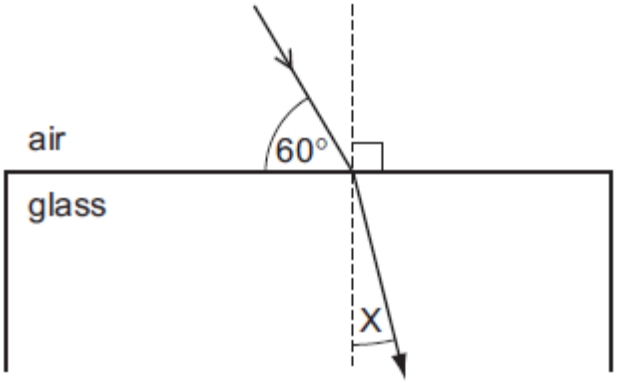
D 14.4 cm / s

3. The diagram shows a ray of light travelling from X. Angle P is less than the critical angle.

In which direction does the ray continue?



4. A ray of light passes into a glass block of refractive index 1.5.



What is the value of the angle marked X?

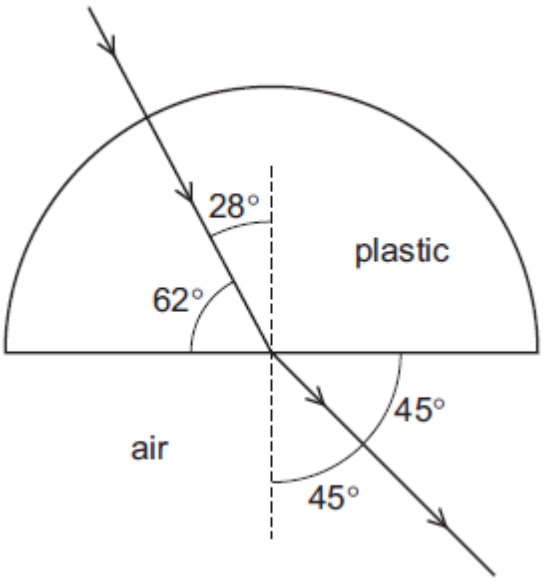
A. 19.5°

B. 25.0°

C. 35.3°

D. 48.6°

5. A semi-circular block is made from a plastic. A ray of light passes through it at the angles shown.



To two decimal places, what is the refractive index of the plastic?

[3m]

6. Fig. 6.1 shows a ray of white light from a ray-box passing into a glass prism. A spectrum is formed between P and Q on the screen.

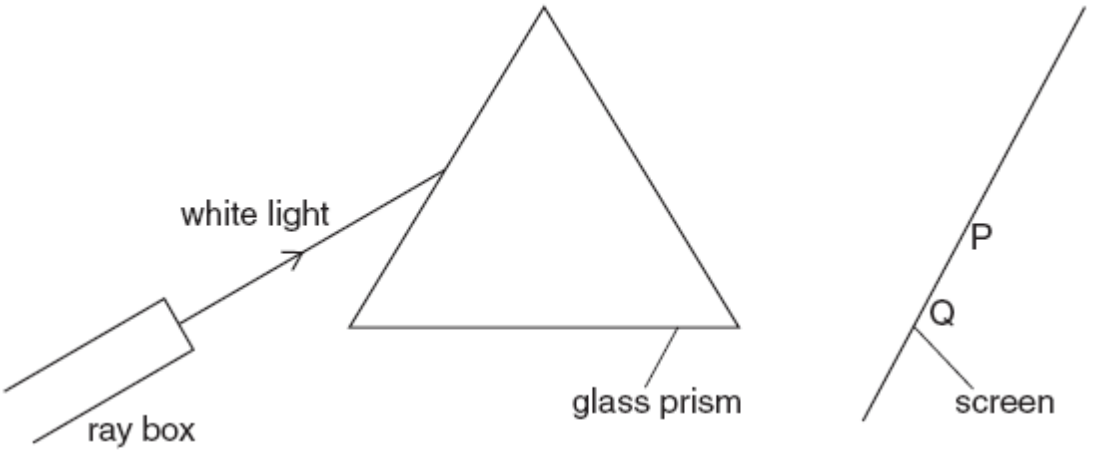


Fig. 6.1

(a) State the colour of the light at end P of the spectrum.

[1]

(b) State whether the value of each of these properties for blue light is greater than, equal to or less than the value for red light.

(i) Speed in a vacuum..... [1]

(ii) Wavelength..... [1]

(c) Fig. 6.2 shows the ray passing through a red filter before it reaches the prism.

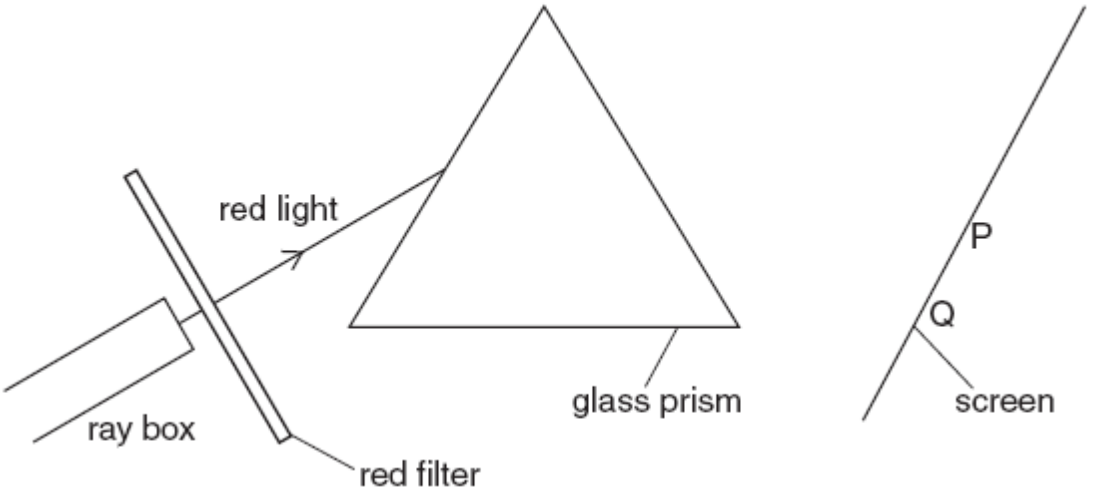
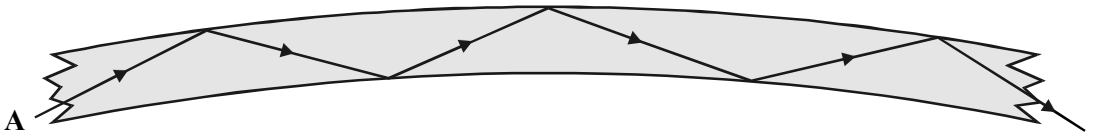


Fig. 6.2

Complete Fig. 6.2 to show the ray of red light passing through and emerging from the prism. [2]

7. (a) The diagram shows the passage of light beam A travelling down an optical fibre.



(i) State the name of the process that takes place as the light **A** beam travels down the optical fibre.

.....

(1)

(ii) Complete the diagram to show the passage of the light beam **B** down the same optical fibre.

(1)

(iii) Suggest why beam **B** will take slightly longer to travel down the fibre than beam **A**.

.....

.....

.....

.....

(2)

(b) Optical fibres are used to carry information. The information is carried by the light beam in the form of a digital signal.

(i) Draw a diagram to show what is meant by a digital signal.

(1)

(ii) The signal from a microphone is an analogue signal. How does an analogue signal differ from a digital signal?

.....

.....

(1)

(c) When signals are sent through optical fibres they lose energy.

(i) State what happens to the brightness of the light beam as it loses energy.

.....

(1)

(ii) State **one** disadvantage of losing energy as the light beam travels through the optical fibre.

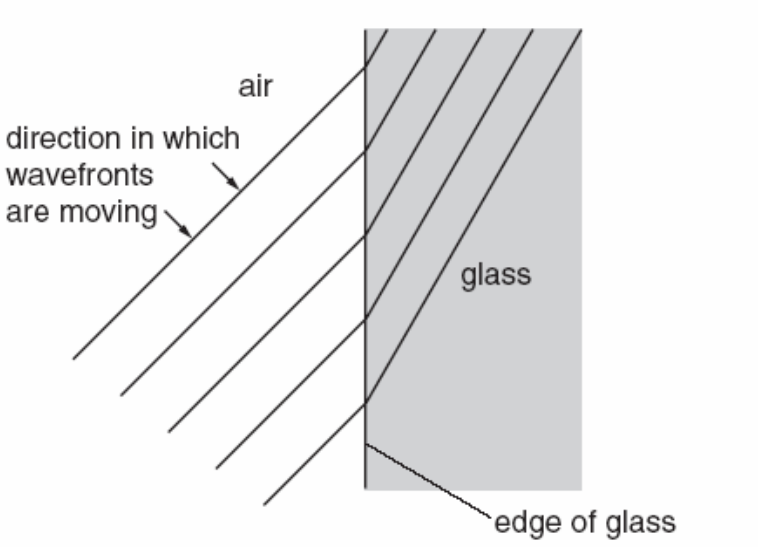
.....

.....

(1)

(Total 8 marks)

8. The figure below shows wavefronts of light crossing the edge of a glass block from air into glass.



(a) On the figure:
(i) draw in an incident ray, a normal and a refracted ray that meet at the same point on the edge of the glass block,
(ii) label the angle of incidence and the angle of refraction,
(iii) measure the two angles and record their values.

Angle of incidence = ...

Angle of refraction = ...

[4]

(b) Calculate the refractive index of the glass.

Refractive index = ...[3]

[Total 7m]

9. Fig. 7.1 and Fig. 7.2 show wavefronts of light approaching a plane mirror and a rectangular glass block, respectively.

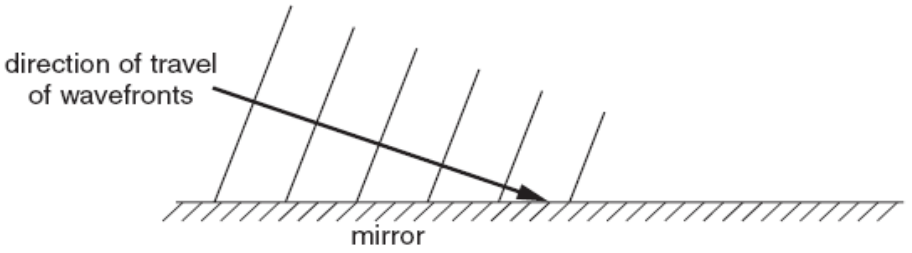


Fig. 7.1

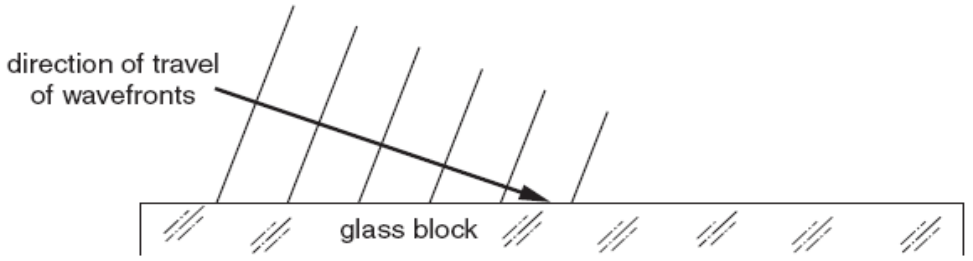


Fig. 7.2

(a) On Fig. 7.1 and on Fig. 7.2 draw wavefronts to show what happens after the waves
strike the surface. [4]
(b) In Fig. 7.2, the waves approaching the block have a speed of 3.0×10^8 m/s and an angle
of incidence of 70°. The refractive index of the glass of the block is 1.5.
(i) Calculate the speed of light waves in the block.

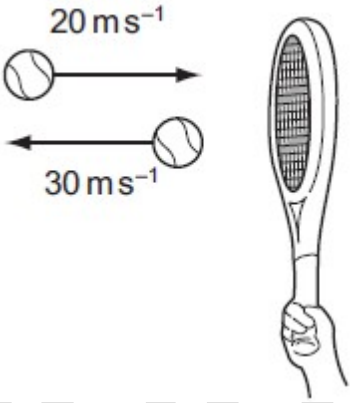
Speed = ... [2]
(ii) Calculate the angle of refraction in the block.

Angle =..... [2]
[Total: 8]

NAME: .....

NEWTONS LAWS OF MOTION

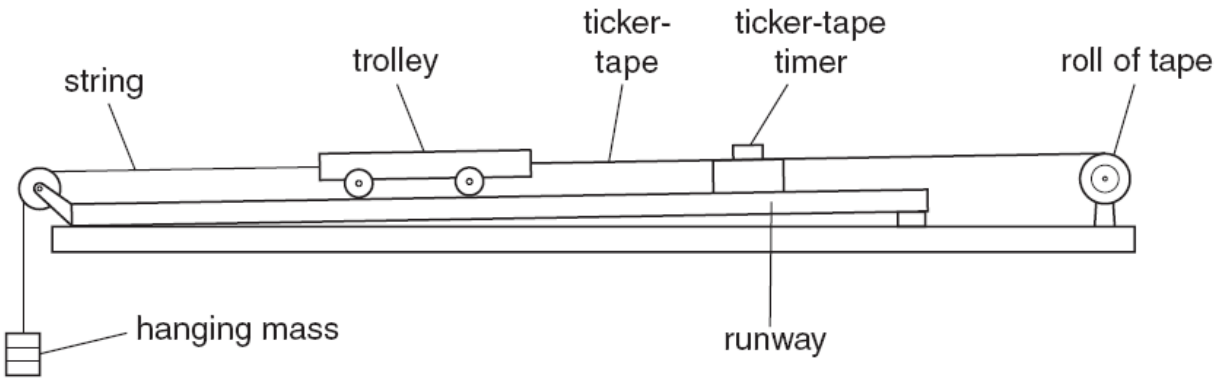
1. A tennis ball of mass 100 g is struck by a tennis racket. The velocity of the ball is changed as shown.



What is the magnitude of the change in momentum of the ball?

[2m]

2. The figure shows apparatus used to find a relationship between the force applied to a trolley and the acceleration caused by the force.



For each mass, hung as shown, the acceleration of the trolley is determined from the tape.
Some of the results are given in the table below.

weight of the hanging mass/N	acceleration of the trolley / m/s^2
0.20	0.25
0.40	0.50
0.70	
0.80	1.0

(a) (i) Explain why the trolley accelerates.

[2]

(ii) Suggest why the runway has a slight slope as shown.

[1]

(b) Calculate the mass of the trolley, assuming that the accelerating force is equal to the weight of the hanging mass.

mass = ... [2]

(c) Calculate the value missing from the table. Show your working.

Value = ... [2]

(d) In one experiment, the hanging mass has a weight of 0.4 N and the trolley starts from rest.
Use data from the table to calculate;

(i) The speed of the trolley after 1.2 s,

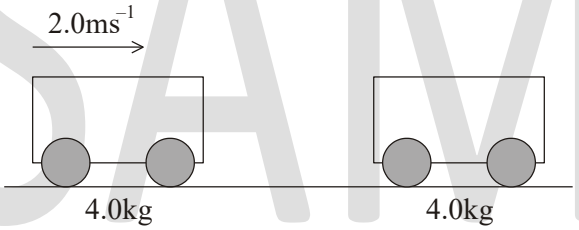
speed = ... [2]

(ii) The distance travelled by the trolley in 1.2 s.

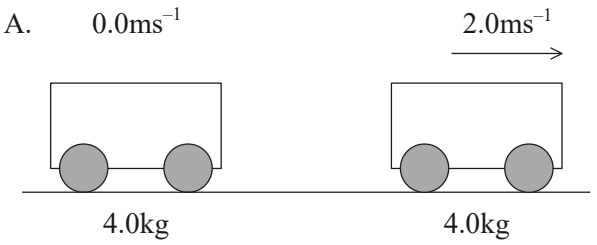
distance = ... [2]

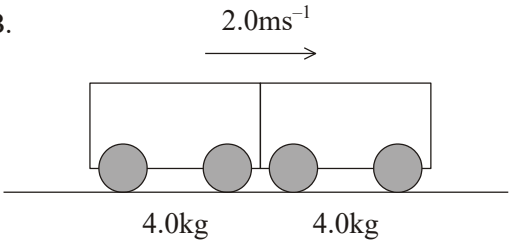
[Total: 11]

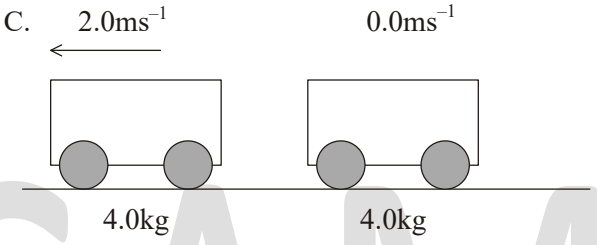
3. The diagram below shows a trolley of mass 4.0 kg moving on a frictionless horizontal table with a speed of 2.0 m s^{-1}. It collides with a stationary trolley also of mass 4.0 kg.

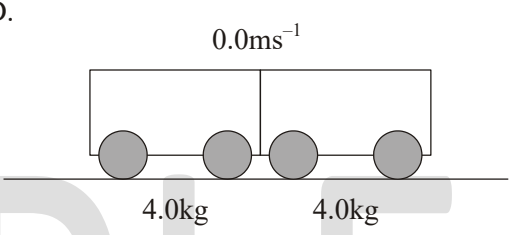


Which of the following diagrams shows a possible outcome?

A. 

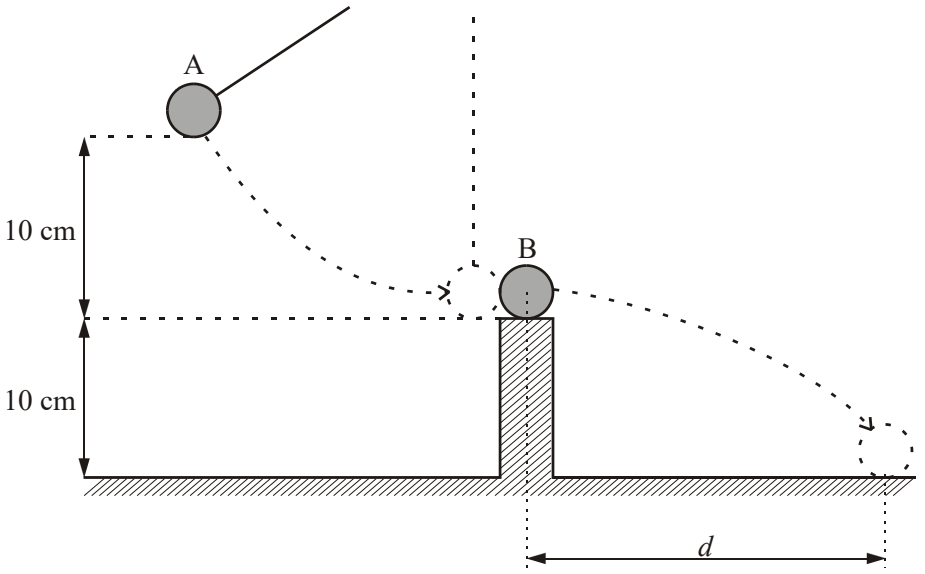
B. 

C. 

D. 

(1)

4. The diagram illustrates an elastic collision between two spheres, A and B, of equal mass.



Sphere A is tied to the end of a long vertical thread and pulled to one side until it has risen a distance of 10 cm. It is then released and comes to rest when it strikes the sphere B which is resting on a smooth flat support.

Sphere B travels a horizontal distance *d* before it hits the ground after falling 10 cm.

Calculate the speed of A as it strikes B.

.....

.....

.....

.....

Speed = ...

(4)

How long does B take to fall 10cm?

.....

.....

.....

Time= .....

(3)

What is the speed of B just after the collision?

.....

(1)

Calculate the distance *d*

.....

.....

Distance = ...

(2)

Explain briefly why B drops a distance of 10 cm much more quickly than A.

.....

.....

.....

.....

(2)

(Total 12 marks)

5. This question is about momentum.

(a) Define

(i) *linear momentum*.

.....

.....

(1)

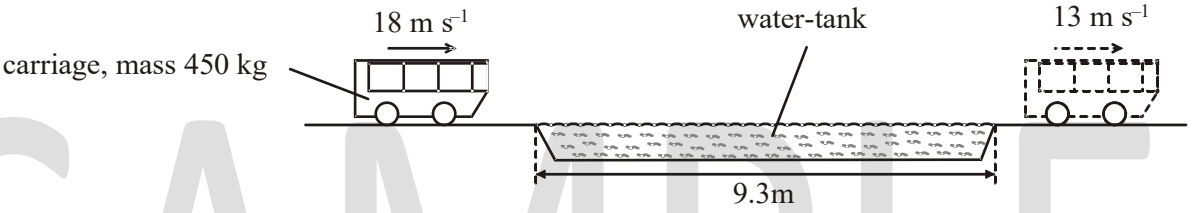
(ii) *impulse*.

.....

.....

(1)

(b) In a ride in a pleasure park, a carriage of mass 450 kg is travelling horizontally at a speed of 18 m s^{-1}. It passes through a shallow tank containing stationary water. The tank is of length 9.3 m. The carriage leaves the tank at a speed of 13 m s^{-1}.



As the carriage passes through the tank, the carriage loses momentum and causes some water to be pushed forwards with a speed of 19 m s^{-1} in the direction of motion of the carriage.

(i) For the carriage passing through the water-tank, deduce that the magnitude of its total change in momentum is 2250N s.

.....

.....

(1)

(ii) Use the answer in (b)(i) to deduce that the mass of water moved in the direction of motion of the carriage is approximately 120 kg.

.....

.....

.....

(2)

(iii) Calculate the mean value of the magnitude of the acceleration of the carriage in the water.

.....

.....

.....

.....

(3)

(c) For the carriage in (b) passing through the water-tank, determine

(i) its total loss in kinetic energy.

.....

.....

.....

.....

(3)

(ii) the gain in kinetic energy of the water that is moved in the direction of motion of the carriage.

.....

.....

(1)

(d) By reference to the principles of conservation of momentum and of energy, explain your answers in (c).

.....

.....

.....

.....

(3)
(Total 15 marks)

6. This question is about Newton's laws of motion, the dynamics of a model helicopter and the engine that powers it.

(a) Explain how Newton's third law leads to the concept of conservation of momentum in the collision between two objects in an isolated system.

.....

.....

.....

.....

.....

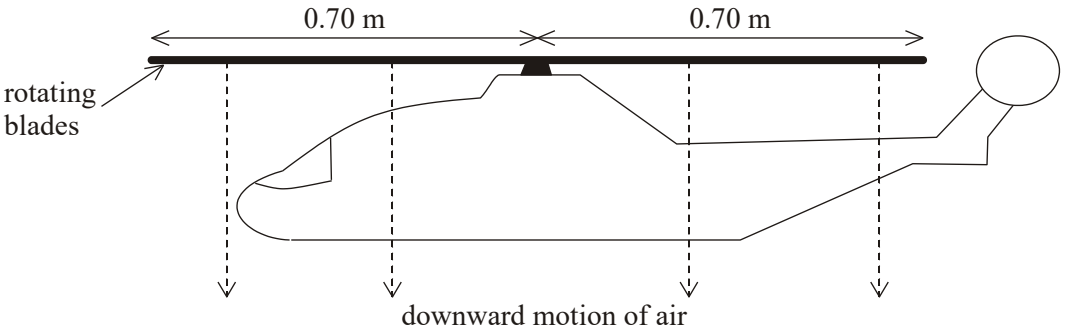
.....

.....

.....

(4)

(b) The diagram illustrates a model helicopter that is hovering in a stationary position.



The rotating blades of the helicopter force a column of air to move downwards. Explain how this may enable the helicopter to remain stationary.

.....

.....

.....

.....

.....

.....

(3)

(c) The length of each blade of the helicopter in (b) is 0.70 m. Deduce that the area that the blades sweep out as they rotate is 1.5 m^2. (Area of a circle = pr^2)

.....

.....

(1)

(d) For the hovering helicopter in (b), it is assumed that all the air beneath the blades is pushed vertically downwards with the same

speed of 4.0 m s^{-1}. No other air is disturbed.

The density of the air is 1.2 kg m^{-3}.

Calculate, for the air moved downwards by the rotating blades,

(i) the mass per second;

.....

.....

.....

.....

(2)

(ii) the rate of change of momentum.

.....

.....

(1)

(e) State the magnitude of the force that the air beneath the blades exerts on the blades.

.....

(1)

(f) Calculate the mass of the helicopter and its load.

.....

.....

.....

.....

(2)

7. (a) State Newton's third law.

.....

.....

.....

(1)

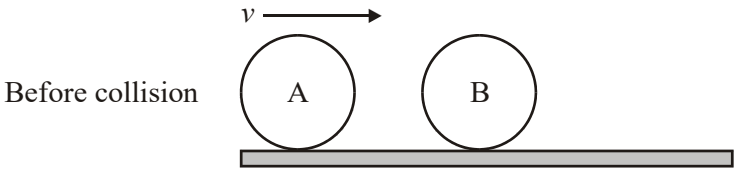
(b) State the law of conservation of momentum.

.....

.....

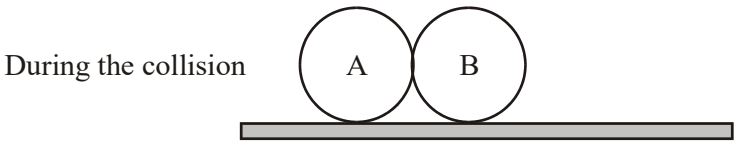
(2)

The diagram below shows two identical balls A and B on a horizontal surface. Ball B is at rest and ball A is moving with speed V along a line joining the centres of the balls. The mass of each ball is M.



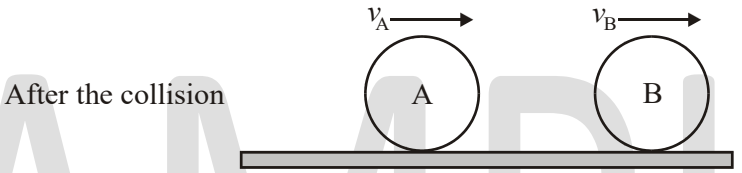
During the collision of the balls, the magnitude of the force that ball A exerts on ball B is FAB and the magnitude of the force that ball B exerts on ball A is FBA.

(c) On the diagram below, add labelled arrows to represent the magnitude and direction of the forces FAB and FBA.



(3)

The balls are in contact for a time Ät. After the collision, the speed of ball A is +vA and the speed of ball B is +vB in the directions shown.



As a result of the collision, there is a change in momentum of ball A and of ball B.

(d) Use Newton's second law of motion to deduce an expression relating the forces acting during the collision to the change in momentum of

(i) ball B.

.....

.....

(2)

(ii) ball A.

.....

.....

(2)

(e) Apply Newton's third law and your answers to (d), to deduce that the change in momentum of the system (ball A and ball B) as a result of this collision, is zero.

.....

.....

.....

.....

.....

(4)

(f) Deduce, that if kinetic energy is conserved in the collision, then after the collision, ball A will come to rest and ball B will move with speed V.

.....

.....

.....

.....

.....

(3)

(Total 17 marks)

PEAK SUCCESS EDUCATION
Kenya Certificate of Secondary Education

NAME: ……..……..……

SCHOOL:……

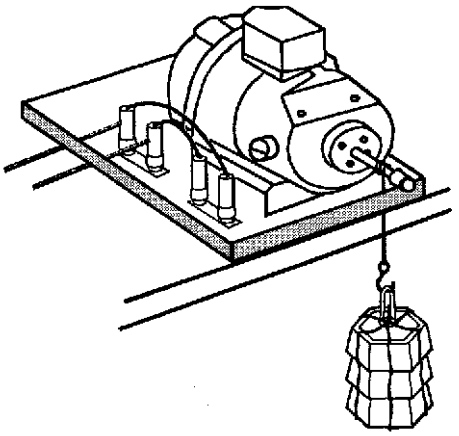
DATE: .....

WORK ENERGY POWER AND MACHINES

INSTRUCTIONS TO CANDIDATES

*Answer **ALL** questions in this paper in the spaces provided.*

1. (a) An electric motor is used to raise a mass of 1.5 kg through a vertical height of 1.2 m. The load is raised at a steady speed.



(i) Calculate the increase in gravitational potential energy of the load when it is raised through 1.2 m.
The gravitational field strength is 10 N/kg.

.....

.....

.....

(3)

(ii) The time taken to raise the load is 4.0 s.
Calculate the power output of the electric motor as it raises the load.

.....

.....

.....

(3)

(iii) The input power to the motor as it raises the load is 30W.
Calculate the efficiency of the motor.

.....

.....

.....

(3)

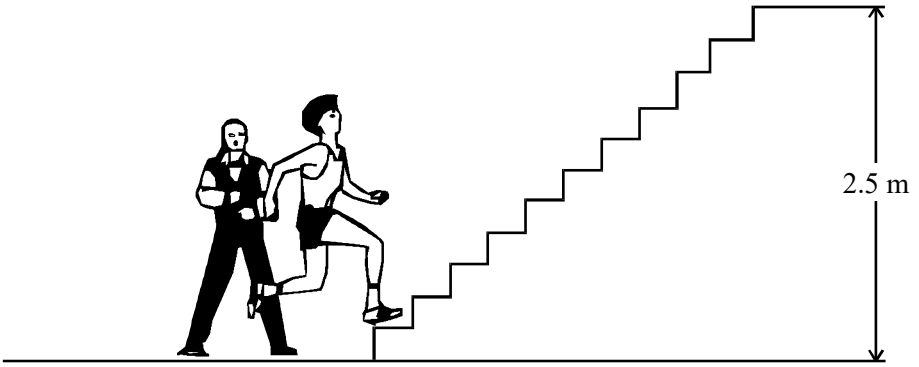
(b) Suggest a reason why the power given out by the motor is less than the power put in.

.....

.....

(1)
(Total 10 marks)

2. (a) Two friends are calculating the power needed to climb some steps.
The girl measures how long the boy takes to run up the steps shown in the diagram.



(i) The value of g is 10 N/kg. The mass of the boy is 50 kg.

Calculate his weight.

.....

.....

.....

(3)

(ii) The vertical height of the steps is 2.5 m.

How much work did the boy do in climbing the steps?

.....

.....

.....

(3)

(iii) It took the boy 5 seconds to run up the steps. Using

$$\text{power} = \frac{\text{work done}}{\text{time taken}}$$

calculate the power developed by the boy as he ran up the steps.

.....

.....

.....

(2)

(b) The girl then tried the experiment and took 3 seconds to run up the steps.
Her weight is the same as the boy's.
Was her power output more or less than his?

Explain how you decided.

.....

.....

.....

(2)
(Total 10 marks)

3. (a) A car is travelling along a straight flat road at 30 m/s.

(i) What type of energy does it have?

.....

(1)

(ii) When the brakes are applied the car is brought to a stop. What has happened to the energy it had whilst moving?

.....

.....

(1)

(b) The car starts going up a hill. The driver notices that the speed of the car begins to decrease. He has not applied the brakes or altered the setting on the accelerator.

Explain in terms of energy why the car's speed begins to decrease.

.....

.....

(2)

(c) When the driver brakes, the distance needed to stop the car moving at 30 m/s up a hill is less than the distance on a flat road.

Explain why.

.....

....

(1)

(d) A journey involving a lot of speeding up and slowing down uses more petrol than one where the speed remains fairly constant.

Explain this in terms of energy.

.....

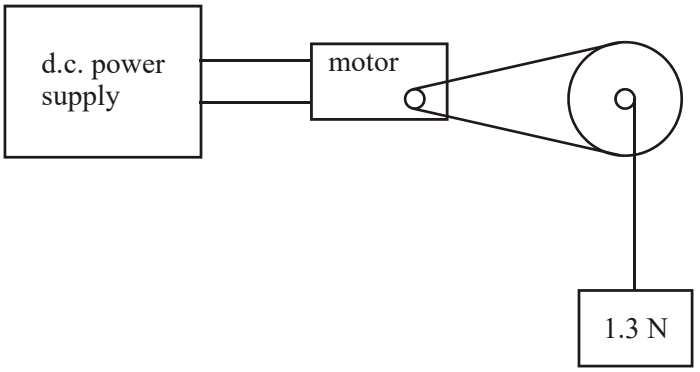
.....

.....

(3)
(Total 8 marks)

4. The diagram shows a small electric motor being used to lift a weight of 1.3 N.

The power input to the motor from the supply is 0.6 W.



(a) The gravitational potential energy of the weight increases by 1.04 J in 4 s.

(i) Calculate the rate at which the weight gains gravitational potential energy.

.....

.....

(2)

(ii) Calculate the height through which the weight is lifted in 4 s.

State the equation you use in your calculation.

.....

.....

....

(3)

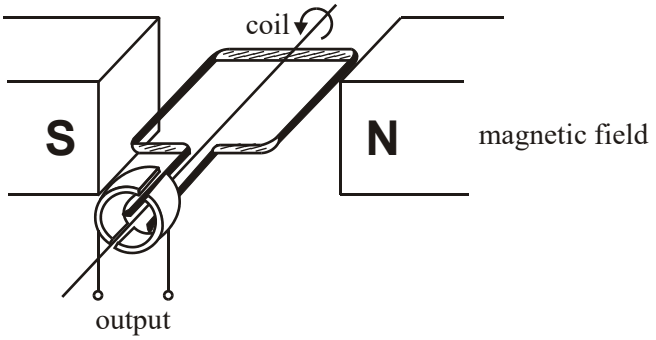
(iii) Calculate the efficiency of the motor.

.....

.....

(2)

(b) (i) The raised weight is held in place whilst the power supply is disconnected and a small lamp is connected across the output to the motor. The weight is released and the lamp lights.



Explain this with reference to the diagram of the motor.

.....

.....

.....

.....

(2)

(ii) The brightness of the lamp is observed to increase as the weight falls.

Explain this.

.....

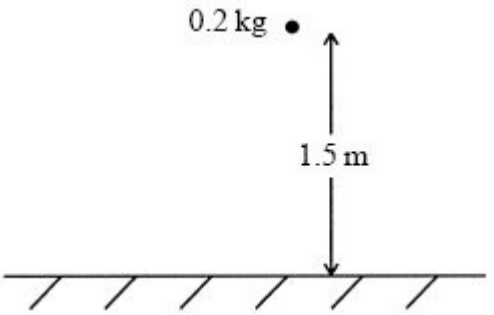
.....

.....

(2)

(Total 11 marks)

5. The diagram shows a ball of mass 0.2 kg held 1.5 m above the ground.



(a) Calculate the gravitational potential energy of the ball.

Assume that the gravitational field strength is 10 N/kg.

.....

.....

.....

.....

(2)

(b) State the value of the kinetic energy of the ball just as it reaches the ground.

.....

(1)

(c) Show that just as the ball reaches the ground it has a speed of approximately 5.5 m/s.

.....

.....

.....

.....

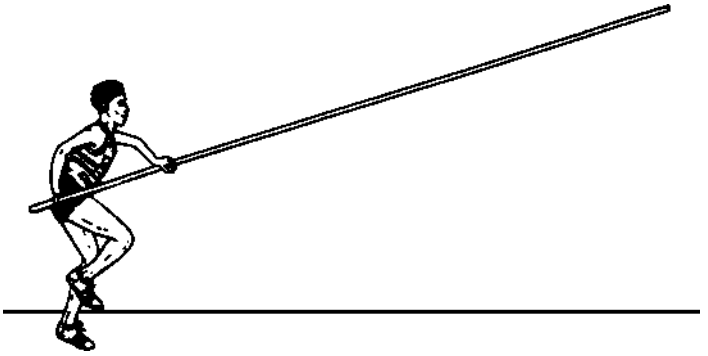
.....

.....

(2)

(Total 5 marks)

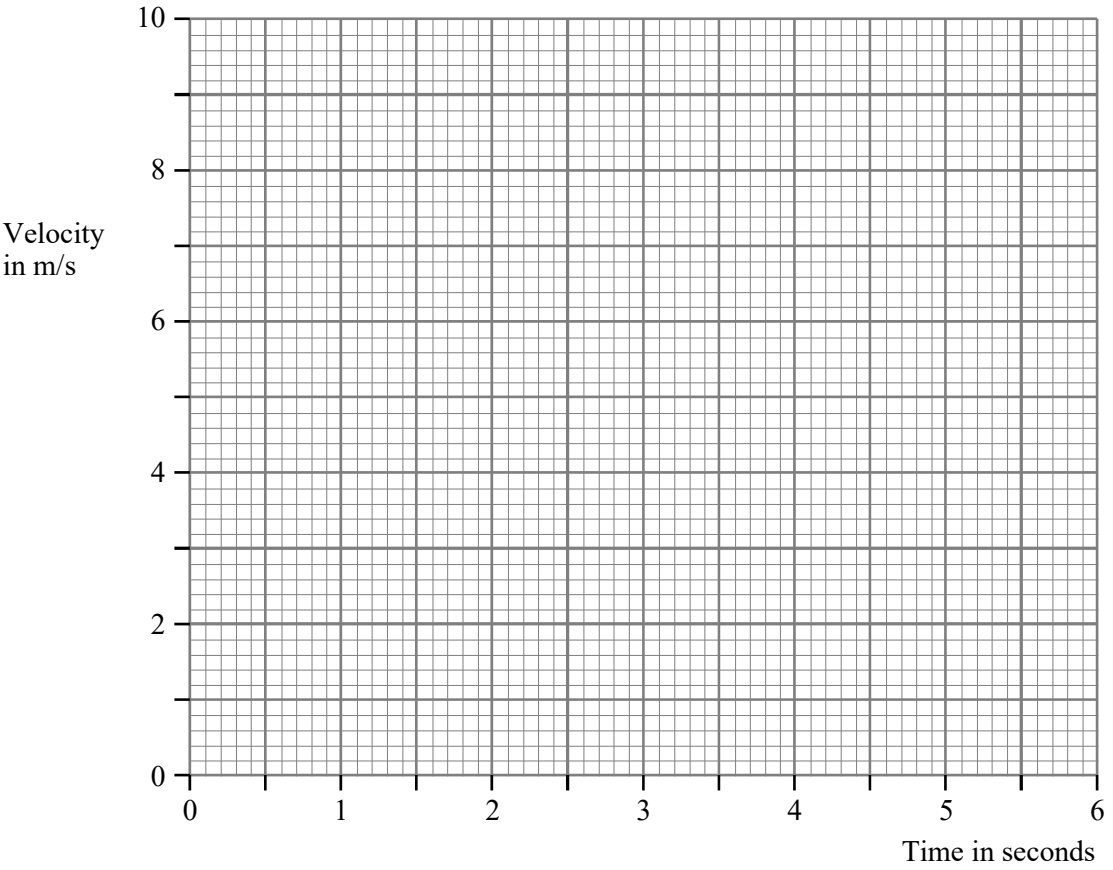
6. In an athletics competition, Tim competes in the pole vault.



The table shows how Tim's velocity changes during his run up.

Velocity (m/s)	0	2.8	5.0	6.8	8.0	8.6	8.6
Time (s)	0	1.0	2.0	3.0	4.0	5.0	6.0

(a) (i) Draw a graph of his velocity against time.



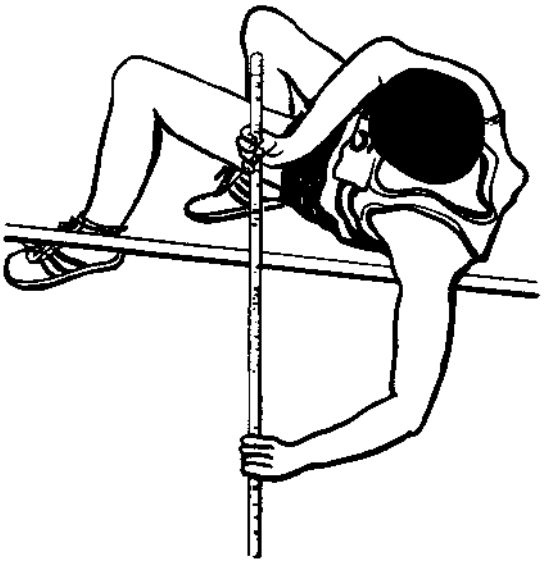
(3)

(ii) Use your graph to find his velocity at 3.5 seconds.

.....

(1)

(b) Tim weighs 750 N.



Calculate the work Tim would need to do to raise his body 4.0 m vertically.
State the unit in your answer.

.....

.....

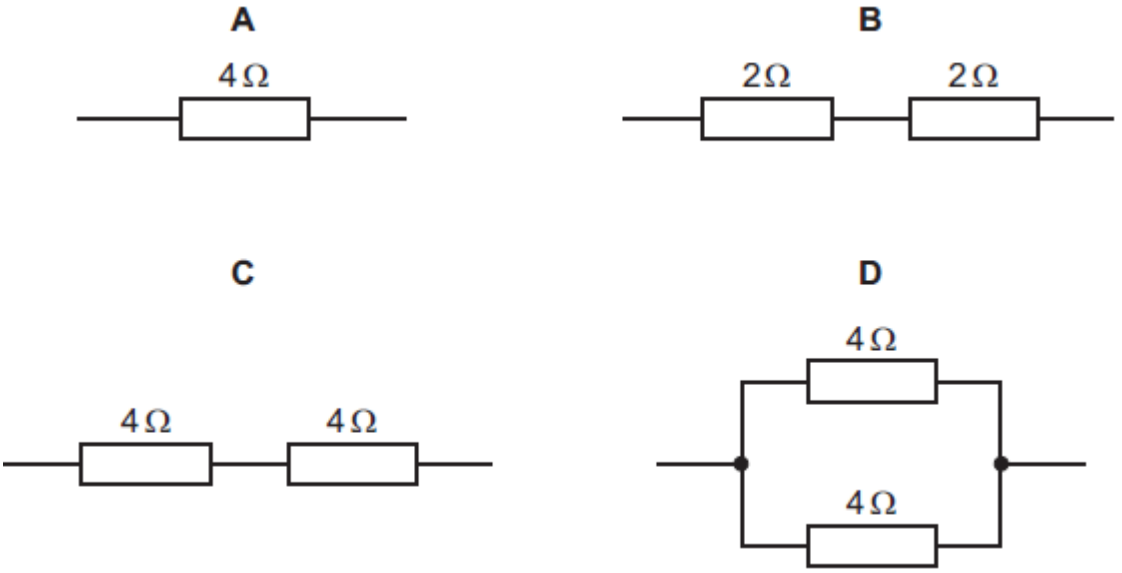
.....

(3)
(Total 7 marks)

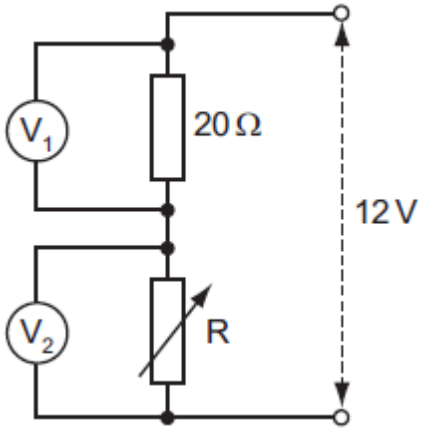
NAME: .....

CURRENT ELECTRICITY

1. The diagrams show four arrangements of resistors.
Which arrangement has the smallest total resistance?



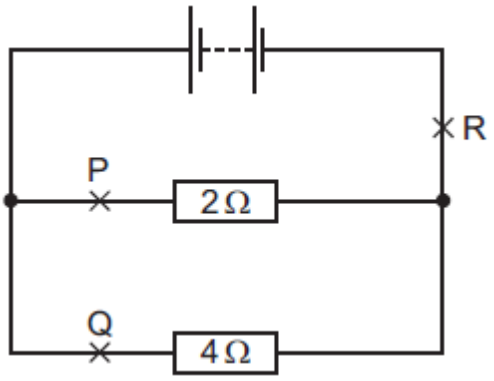
2. The potential divider shown is connected across a constant 12 V supply.



When R has a value of 20 ƒ¶, the voltmeter readings are equal.
How do these readings change when the value of R is reduced to 10 ƒ¶?

	reading on V_1	reading on V_2
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

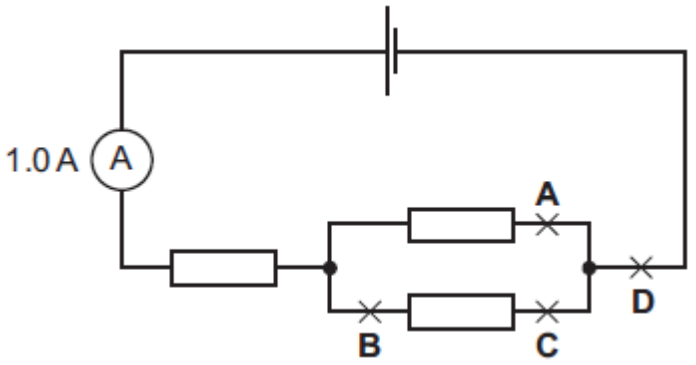
3. A circuit contains two resistors connected in parallel with a battery.



Which of the following statements about the currents at P, Q and R is true?

A. The current at P is the greatest.
B. The current at Q is the greatest.
C. The current at R is the greatest.
D. The current is the same at points P, Q and R.

4. The reading on the ammeter in the circuit is 1.0 A.
A second ammeter is connected in the circuit. It also reads 1.0 A.
At which labelled point is it connected?



5. Distinguish between the electromotive force (e.m.f.) of a cell and the potential difference (p.d.) across a resistor.

[3]

6. Three resistors are connected in series across a 75-V potential difference. R_1 is 170Ω and R_2 is 190Ω. The potential difference across R_3 is 21 V.

a. Find the current in the circuit. [2m]

b. Find the resistance of R_3.[1m]

[3m]

7. A cell has electromotive force (e.m.f.) E and internal resistance r. It is connected in series with a variable resistor R, as shown in Fig. 6.1.

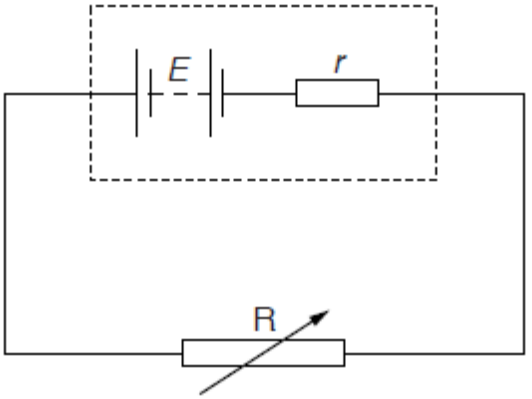


Fig. 6.1

(a) Define electromotive force (e.m.f.).

[2]

(b) The variable resistor R has resistance X. Show that;

$$\frac{\text{power dissipated in resistor R}}{\text{power produced in cell}} = \frac{X}{X + r}$$

[3]

(c) The variation with resistance X of the power P_R dissipated in R is shown in Fig. 6.2.

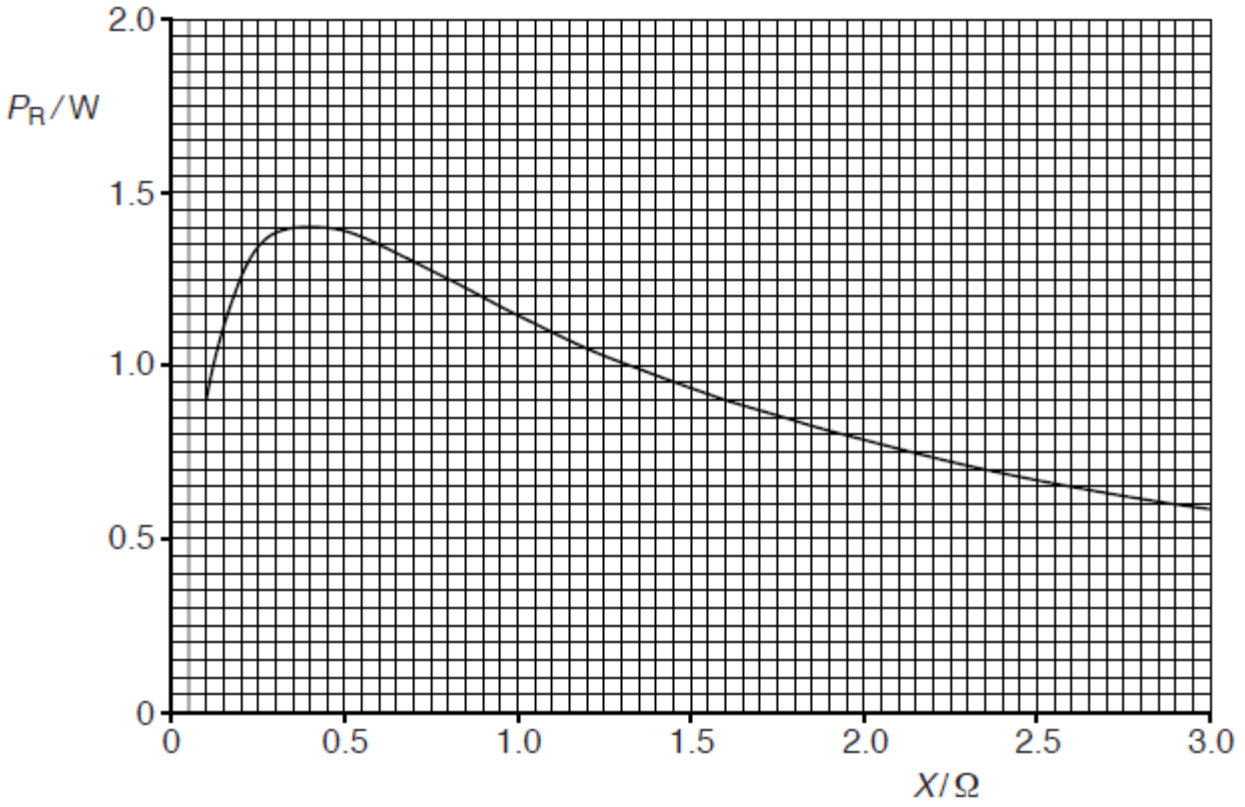


Fig. 6.2

(i) Use Fig. 6.2 to state, for maximum power dissipation in resistor R, the magnitude of this power and the resistance of R.

Maximum power = ... W

Resistance = ... Ω

[2]

(ii) The cell has e.m.f. 1.5 V.
Use your answers in (i) to calculate the internal resistance of the cell.

internal resistance = ... Ω [3]

(d) In Fig. 6.2, it can be seen that, for larger values of X, the power dissipation decreases. Use the relationship in (b) to suggest one advantage, despite the lower power output, of using the cell in a circuit where the resistance X is larger than the internal resistance of the cell.

[1]

8. A car battery has an internal resistance of 0.060 Ω. It is re-charged using a battery charger having an e.m.f. of 14 V and an internal resistance of 0.10 Ω, as shown in Fig. 6.1.

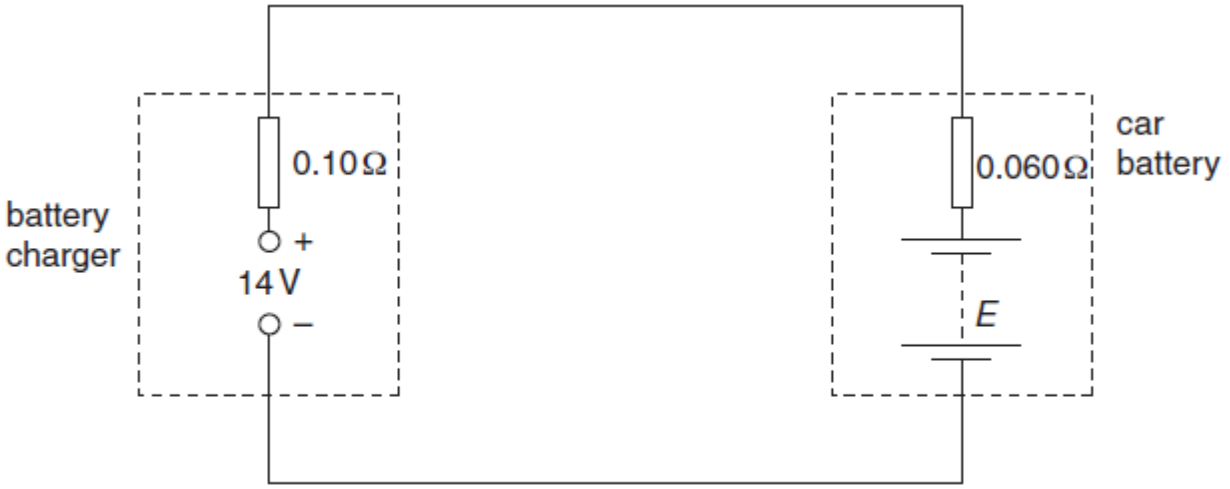


Fig. 6.1

(a) At the beginning of the re-charging process, the current in the circuit is 42 A and the e.m.f. of the battery is E (measured in volts).
(i) For the circuit of Fig. 6.1, state
1. the magnitude of the total resistance,

Resistance = ... Ω

2. the total e.m.f. in the circuit. Give your answer in terms of E.

e.m.f. = ... V
[2]

(ii) Use your answers to (i) and data from the question to determine the e.m.f. of the car battery at the beginning of the re-charging process.

e.m.f. = ...V [2]

(b) For the majority of the charging time of the car battery, the e.m.f. of the car battery is 12 V and the charging current is 12.5 A. The battery is charged at this current for 4.0 hours.
Calculate, for this charging time,
(i) The charge that passes through the battery,

Charge = ...C [2]

(ii) The energy supplied from the battery charger,

Energy = ...J [2]

(iii) the total energy dissipated in the internal resistance of the battery charger and the car battery.

energy = ...J [2]

(c) Use your answers in (b) to calculate the percentage efficiency of transfer of energy from the battery charger to stored energy in the car battery.

efficiency = ...% [2]

NAME: .....

WAVES II

1. A double-slit interference experiment is set up using coherent red light as illustrated in Fig. 5.1.

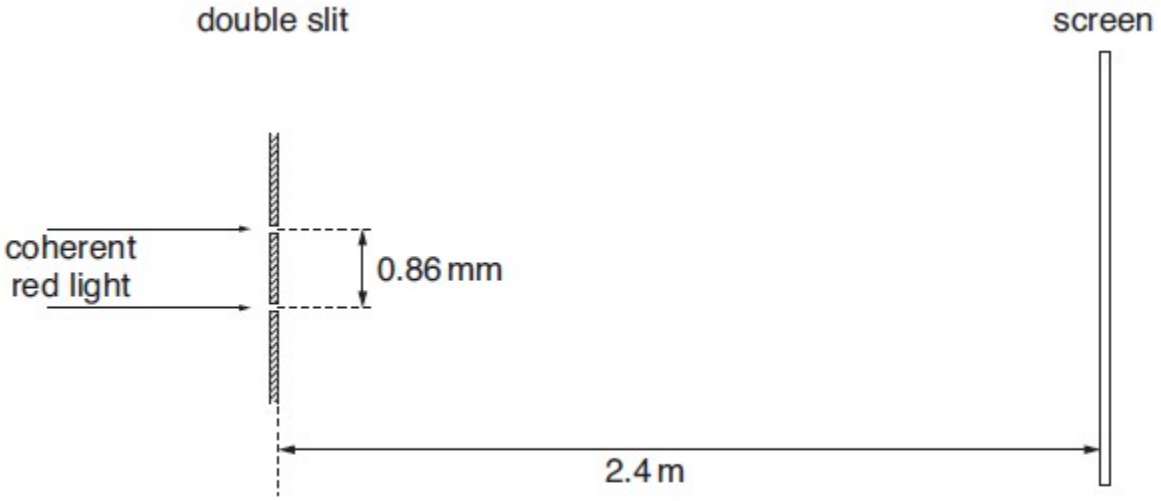


Fig. 5.1 (not to scale)

The separation of the slits is 0.86 mm.
The distance of the screen from the double slit is 2.4 m.
A series of light and dark fringes is observed on the screen.

(a) State what is meant by *coherent* light.[1m]

(b) Estimate the separation of the dark fringes on the screen. [3m]

Separation = ...mm

(c) Initially, the light passing through each slit has the same intensity.
The intensity of light passing through one slit is now reduced.
Suggest and explain the effect, if any, on the dark fringes observed on the screen.

[2m]

2. (a) Define *refractive index*.

.....

.....

(1)

(b) In a certain medium, the speed of light of a particular frequency is 2.1×10^8 m s^{-1}. Calculate the refractive index of the medium for this frequency.

.....

.....

.....

(2)

(c) With reference to your answer in (b), describe what is meant by optical dispersion.

.....

.....

.....

.....

.....

(3)
(Total 6 marks)

3. (i) Outline the conditions necessary for the formation of a standing (stationary) wave.

.....

.....

.....

(2)

(ii) A horizontal tube, closed at one end, has some fine powder sprinkled along its length. A source S of sound is placed at the open end of the tube, as shown below.

The frequency of the source S is varied. Explain why, at a particular frequency, the powder is seen to form small equally-spaced heaps in the tube.

.....

.....

.....

(2)

(iii) The mean separation of the heaps of powder in (b)(ii) is 9.3 cm when the frequency of the source S is 1800 Hz. Calculate the speed of sound in the tube.

.....

.....

.....

(2)

(c) The experiment in (b)(ii) is repeated on a day when the temperature of the air in the tube is higher. The mean separation of the heaps is observed to have increased for the same frequency

of the source S. Deduce qualitatively the effect, if any, of temperature rise on the speed of the sound in the tube.

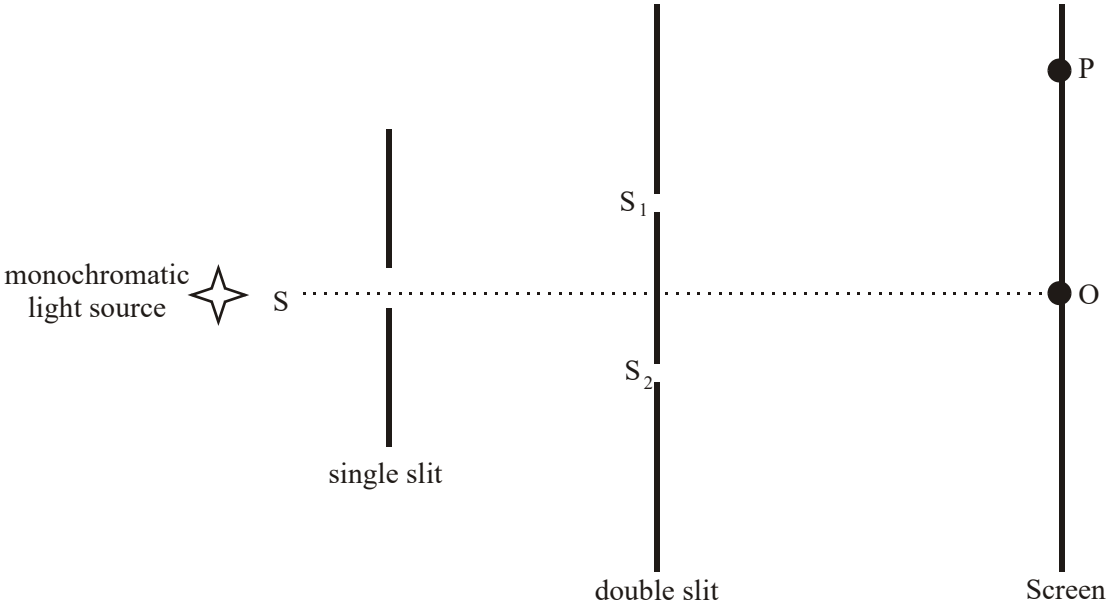
.....

.....

.....

(2)

4. The diagram below shows an arrangement (not to scale) for observing the interference pattern produced by the superposition of two light waves.



S_1 and S_2 are two very narrow slits. The single slit S ensures that the light leaving the slits S_1 and S_2 is coherent.

(i) Define *coherent*.

.....

.....

(1)

(ii) Explain why the slits S_1 and S_2 need to be very narrow.

.....

.....

.....

.....

(2)

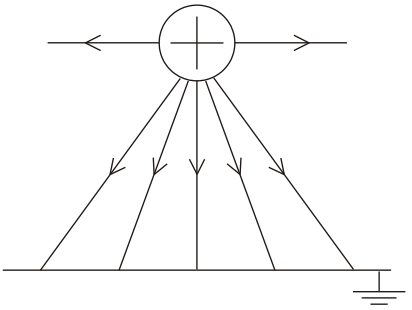
NAME: .....

PHYSICS

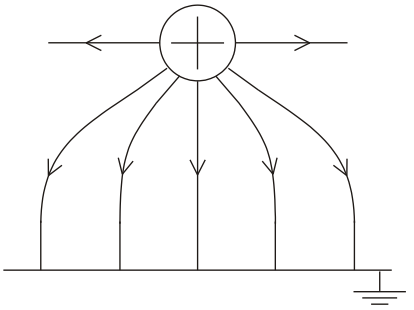
ELECTROSTATICS II

1. Which diagram below best represents the electric field pattern between a positively charged conducting sphere and an earthed metal plate?

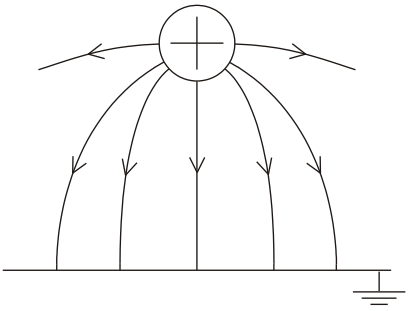
A.



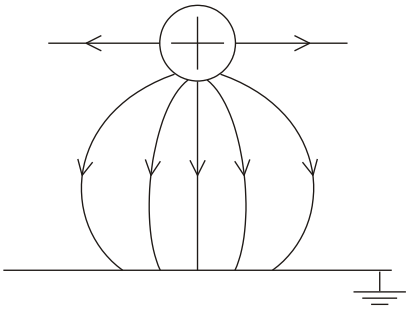
B.



C.

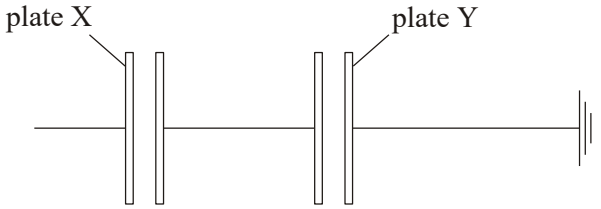


D.

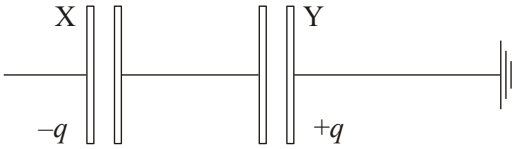


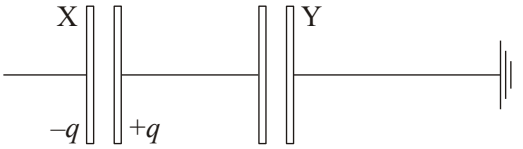
(1)

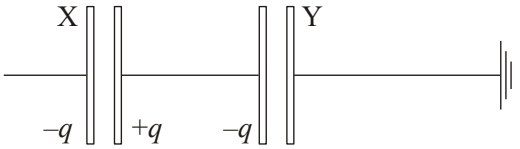
2. Two pairs of uncharged parallel plates are placed in a vacuum and are connected as shown.

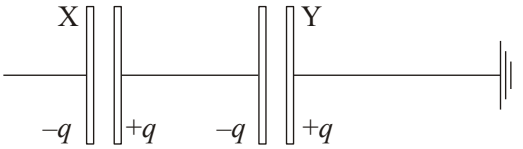


A negative charge of magnitude *q* is placed on plate X. Plate Y is connected to earth.
Which **one** of the following diagrams shows the distribution of charge on the plates?

A. 

B. 

C. 

D. 

(1)

3. Which of the following is the correct value of the electronvolt, measured in SI Units?

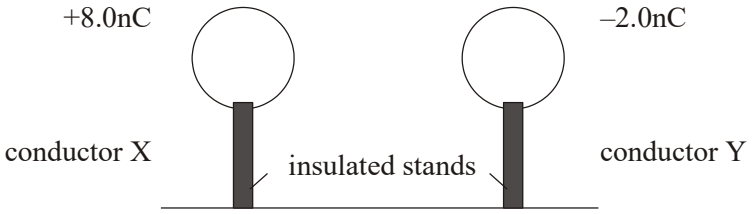
A. 1.6×10^{-19} N

B. 1.6×10^{-19} J

C. 9.1×10^{-31} N

D. 9.1×10^{-31} J

4. Two identical spherical conductors X and Y are mounted on insulated stands. X carries a charge of +8.0 nC and Y carries a charge of -2.0 nC.



The two conductors are brought into contact and are then separated. Which of the following gives the charge on each conductor?

	Charge on X	Charge on Y
A.	0.0 nC	0.0 nC
B.	+8.0 nC	-2.0 nC
C.	+5.0 nC	+5.0 nC

D.	+3.0 nC	+3.0 nC

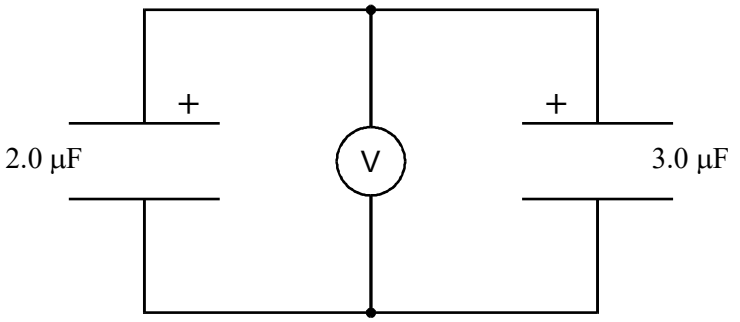
5. A 2.0 μF capacitor is charged to a potential difference (p.d.) of 50 V and a 3.0 μF capacitor is charged to a p.d. of 100 V.

Calculate the charge on the plates of each capacitor.
Write your answers in the table below.

Capacitor	2.0 μF	3.0 μF
P.d.	50 V	100 V
Charge		

(2)

The capacitors are then joined together **in parallel** with their positive plates connected together.



What is the equivalent capacitance of this combination?

.....

Equivalent capacitance = ... μF (1)

[Total 3m]

6. A 3.0 mF and a 5.0 mF capacitor are connected in series with a 12 V battery.

a. Find the equivalent capacitance.

[3m]

b. Find the charge on each capacitor.

[3m]

c. Find the potential drop (or voltage) across each capacitor. 3m

[3m]
[Total 9m]

7. This 8.0 μF 6.0 μF and 5.0 μF capacitors are connected in series. Calculate the total capacitance for this arrangement.

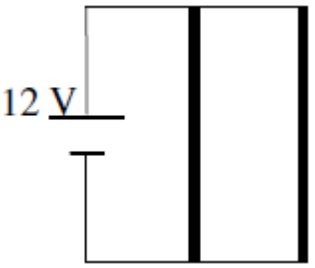
[3m]

NAME: .....

HEATING EFFECT OF ELECTRIC CURRENT

1. A car heater has two identical heating elements. The car battery can send 15000 C through the circuit in an hour.
(i) What is the current in each heating element?

(ii) How much heat is generated by the circuit in an hour?

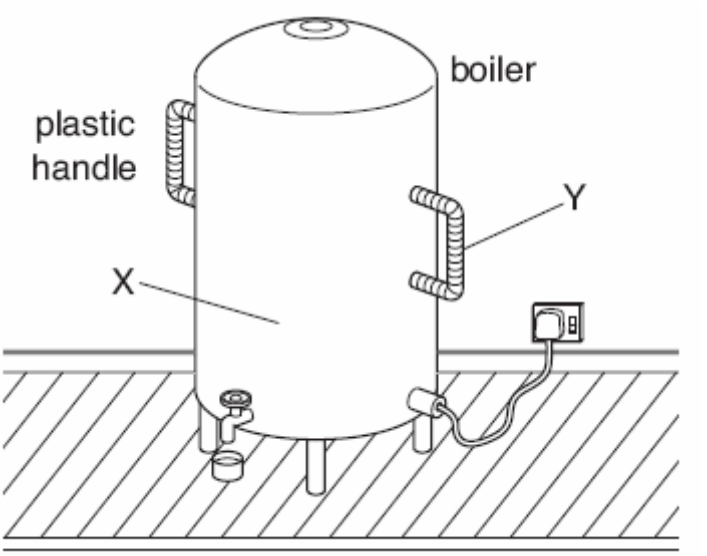


[3m]

2. Calculate the amount of energy possessed by 1.25×10^{-19} electrons at a point where the electric potential is 3.20 volts.

[2m]

3. The Fig. below shows an electric boiler in a school kitchen.



The boiler contains 35 kg of water at 22 °C. The specific heat capacity of water is 4200 J / (kg °C).

(a) (i) Calculate the thermal energy (heat) needed to raise the temperature of the water from 22 °C to its boiling point.

[3]

(ii) The water in the boiler is heated with a 2600 W immersion heater. Calculate the minimum time for the heater to bring the water to its boiling point.

[2]

(iii) Suggest **one** reason why the actual time is greater than the time calculated in **(ii)**.

[1]

(b) (i) The immersion heater is placed in the water at the bottom of the boiler. Explain in detail how this ensures that the thermal energy (heat) is transferred throughout the water.

[4]

(ii) The boiler is made of steel and has two large plastic handles. When the water is boiling, the steel surface at X is hot while the plastic handle at Y is cool. Explain why.

[2]

(c) Before the water reaches boiling point, water vapour is seen escaping from the boiler.
(i) State the name of the process that produces this water vapour.

[1]

(ii) State **two** differences between this process and boiling.

[2]

4. Andrew is set the task of measuring the current-voltage (I-V) characteristics of a filament lamp. The following equipment and information are available.

	Information
Battery	emf = 3.0 V, negligible internal resistance
Filament lamp	marked "3 V, 0.2 A"
Voltmeter	resistance = 30 kW, reads values between 0.0 and 3.0 V
Ammeter	resistance = 0.1 W, reads values between 0.0 and 0.5 A
Potentiometer	resistance = 100 W

(a) For the filament lamp operating at normal brightness, calculate

(i) its resistance;

.....

.....

(1)

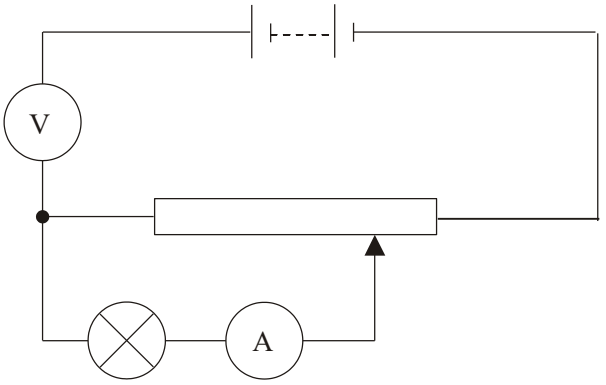
(ii) its power dissipation.

.....

.....

(1)

Andrew sets up the following incorrect circuit.



(b) (i) Explain why the lamp will not light.

.....

.....

.....

(2)

(ii) State the approximate reading on the voltmeter. Explain your answer.

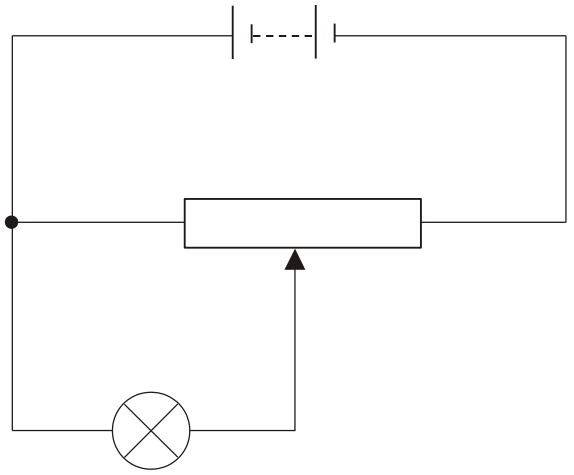
.....

.....

.....

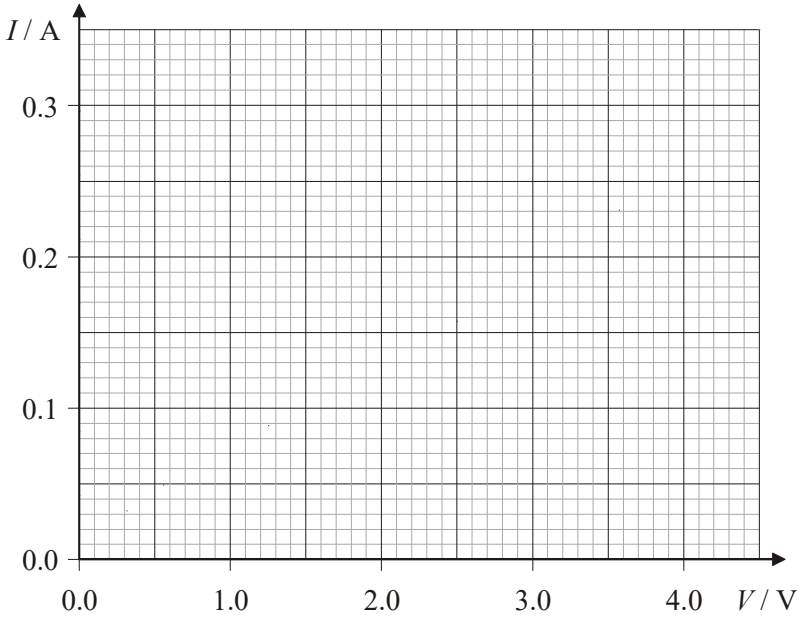
(2)

(c) On the circuit diagram below, add circuit symbols to show the correct position of the ammeter and of the voltmeter in order to measure the I-V characteristics of the lamp.



(2)

(d) On the axes below draw a sketch graph to show the I-V characteristics for this filament lamp.



(4)

(e) Explain the shape of the graph that you have drawn in (d).

.....

.....

.....

.....

(2)
(Total 14 marks)

5. A student places a small electrical heater inside a cup of water, as shown in Fig. 11.1.

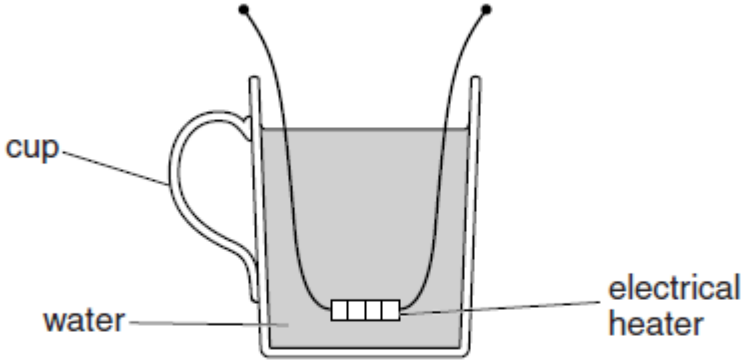


Fig. 11.1

The student determines the electrical power of the heater.
(a) In the space above the cup on Fig. 11.1, draw the electrical circuit that the student uses. Include an ammeter, a voltmeter and a power supply. [2]
(b) The voltage of the power supply is 12 V and the current is 4.2 A.
(i) Calculate the electrical power input to the heater.

Power = ... [2]

(ii) Calculate the energy input to the heater in 8.0 minutes. Give your answer in kW h.

Energy = ... kW h [3]

(c) During heating, the student notices that some of the water evaporates from the cup.
(i) Describe, using ideas about molecules of water, what happens during evaporation.

[2]

(ii) The student finds that the amount of evaporation increases when the temperature of the water is higher.
State and explain one other change that increases the amount of evaporation.

[2]

(iii) State two differences between evaporation and boiling.

[2]

(d) The student turns off the power supply and the water cools.
Describe and explain how convection in the air causes the water to cool.

[2]

[15 Marks]

6. Fig. 9.1a shows a room heater. Fig. 9.1b is a diagram of the electric circuit of the heater.

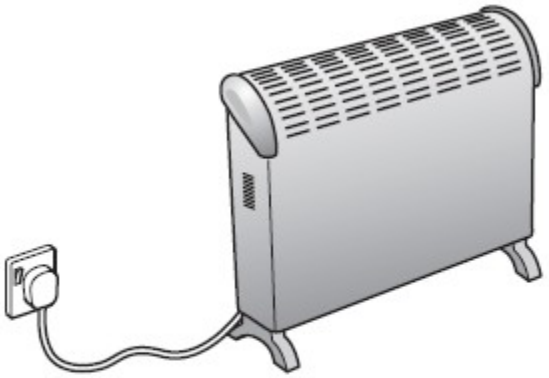


Fig. 9.1a

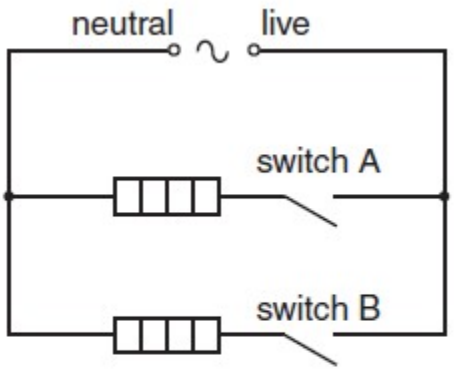


Fig. 9.1b

The fuse has not been drawn on the circuit diagram in Fig. 9.1b.
(a) (i) On Fig. 9.1b, draw the symbol for a fuse in the correct position. [2]
(ii) State the part of the room heater to which the earth wire is connected.

.....[1]

(iii) The earth wire reduces the chance of an electric shock if a fault develops in the room heater.
1. State one fault that causes an electric shock when a person uses the room heater without an earth connection.

[1]
2. Explain how using an earth connection prevents an electric shock.

[2]

(b) (i) This type of room heater is very efficient. Explain what this means.

[1]

(ii) The room heater is a convector heater. Describe and explain how thermal energy (heat) passes around a room by convection.

[3]

(c) Fig. 9.2 shows the power output of the room heater when each switch is closed.

	power / W
switch A only closed	600
switch B only closed	
both switches closed	2100

Fig. 9.2

(i) Determine the power output of the room heater when only switch B is closed.

power output = ... [1]

(ii) The room heater is used with both switches closed for 2.5 hours.
Calculate the energy output of the room heater

1. in kilowatt-hours,

energy = ... kW h [2]

2. in joules.

NAME: ……..……..……

SCHOOL:……

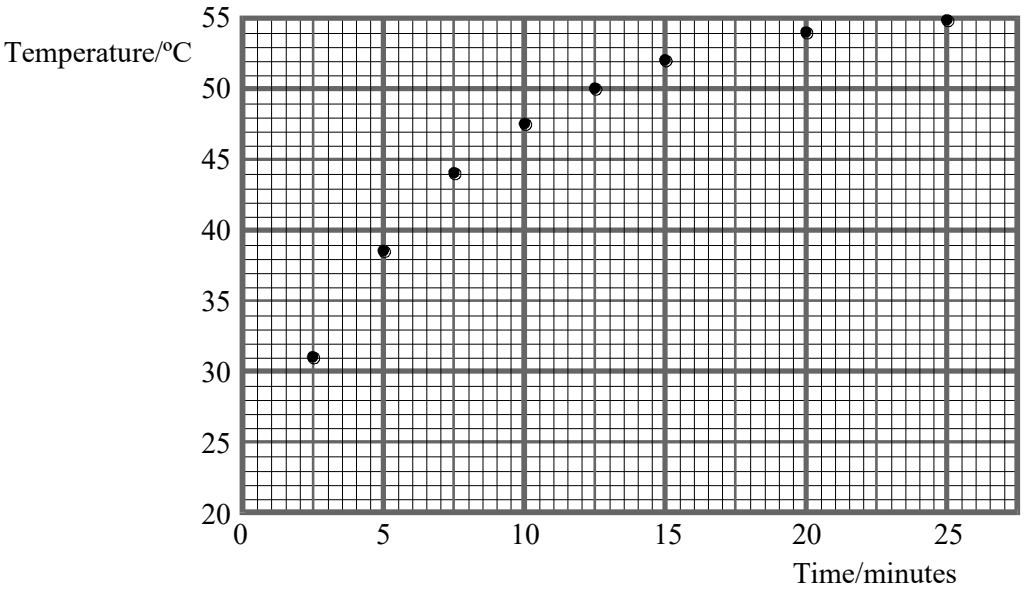
DATE: .....

HEAT ENERGY

INSTRUCTIONS TO CANDIDATES

*Answer **ALL** questions in this paper in the spaces provided.*

1. A student pours 500 g of water into an aluminium saucepan of mass 1.20 kg, heats it over a steady flame and records the temperature as it heats up. The temperatures are plotted as shown below.



Calculate the total heat capacity of the saucepan and water.

Specific heat capacity of water = 4200 J kg^{-1} K^{-1}
Specific heat capacity of aluminium = 900 J kg^{-1} K^{-1}

.....

.....

.....

Heat capacity = ...

(3)

Find the rate of rise of water temperature at the beginning of the heating process.

.....

.....

Rate of rise of temperature = ...

(2)

Hence find the rate at which energy is supplied to the saucepan and water.

.....

.....

Rate of energy supply = ...

(2)

Explain why the rate at which the temperature rises slows down progressively as the heating process continues.

.....

.....

.....

.....

(2)
(Total 9 marks)

2. You are asked to measure the specific heat capacity of aluminium using a cylindrical block of aluminium which has been drilled out to accept an electrical heater.

Draw a complete diagram of the apparatus you would use.

(3)

Describe how you would carry out the experiment and list the measurements you would take.

.....

.....

.....

.....

.....

.....

(5)

Explain how you would calculate the specific heat capacity of aluminium from your measurements.

.....

.....

.....

.....

(3)
(Total 11 marks)

3. A container holding 2.3 litres of milk at 15 °C is put into a freezer. Calculate the energy that must be removed from the milk to reduce its temperature to the freezer temperature of –30°C. Assume that the milk behaves like ice and water.

Specific heat capacity of water = 4.2 kJ kg^{-1} K^{-1}
Specific heat capacity of ice 2.1 kJ kg^{-1} K^{-1}
Specific latent heat (enthalpy) of fusion of ice = 330 kJ kg^{-1}
Density of water = 1.0 kg $litre^{-1}$

.....

.....

.....

Energy removed = ...

(6)

It costs 8.2 p per kWh to remove energy from the freezer. What is the cost of freezing the milk?

.....

.....

Cost = ...

(2)
(Total 8 marks)

4. A small house uses a tank containing 1.2 m^3 water as a thermal store. During the night its temperature rises to 98 °C. During the day, its temperature drops as the water is pumped round the house radiators to keep the house warm.

The density of water is 1 000 kg m^{-3} and its specific heat capacity is 4200 J kg^{-1} K^{-1}. Calculate the energy given out by the water on a day when its temperature drops from 98°C to 65 °C.

.....

.....

.....

Energy = ...

(3)

The six radiators in the house give out an average power of 1.5 kW each. For how long can they all operate at this power before the water temperature drops to 65°C?

.....

.....

.....

Time = ...

(3)

Explain why this heating system operates more effectively early in the morning than towards the evening.

.....

.....

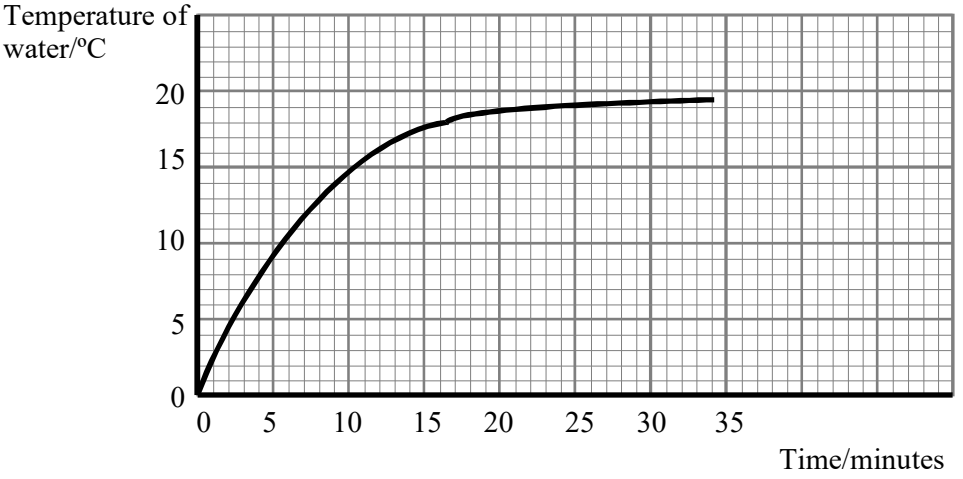
.....

.....

(2)
(Total 8 marks)

5. A thin beaker is filled with 400 g of water at 0°C and placed on a table in a warm room. A second identical beaker, filled with 400 g of an ice-water mixture, is placed on the same table at the same time. The contents of both beakers are stirred continuously.

The graph below shows how the temperature of the water in the *first* beaker increases with time.



Use the graph to find the initial rate of rise of water temperature. Give your answer in Ks^{-1}.

……

……

……

Rate of rise = …….....…….....

(2)

The specific heat capacity of water is 4200 J kg^{-1} K^{-1}. Use your value for the rate of rise of temperature to estimate the initial rate at which this beaker of water is taking in heat from the surroundings.

……

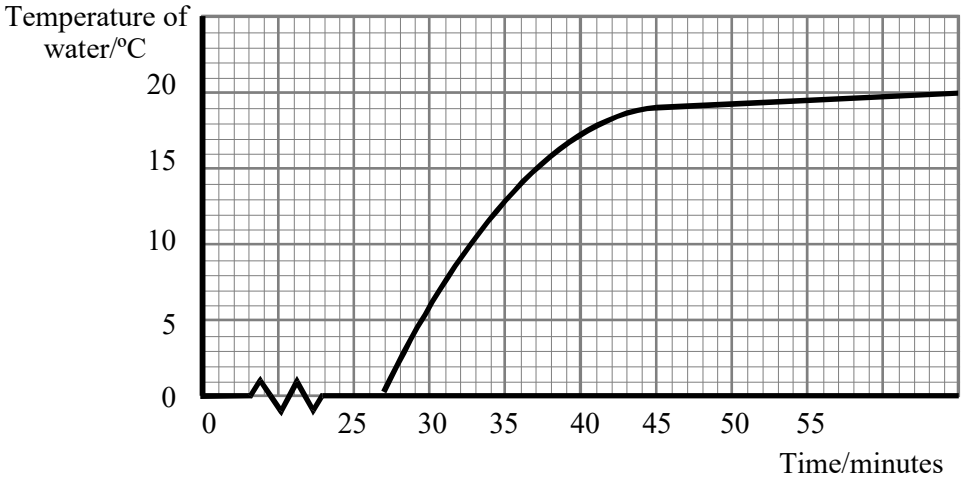
……

……

Rate of heat input = …….....…….....

(3)

The graph below shows the temperature of the water in the second beaker from the moment it is placed on the table.



How do you explain the delay of twenty-seven minutes before the ice-water mixture starts to warm up?

……

……

(2)

The specific latent heat (enthalpy) of ice is 2.27 MJ kg^{-1}. Estimate the mass of ice initially present in the ice-water mixture.

……

……

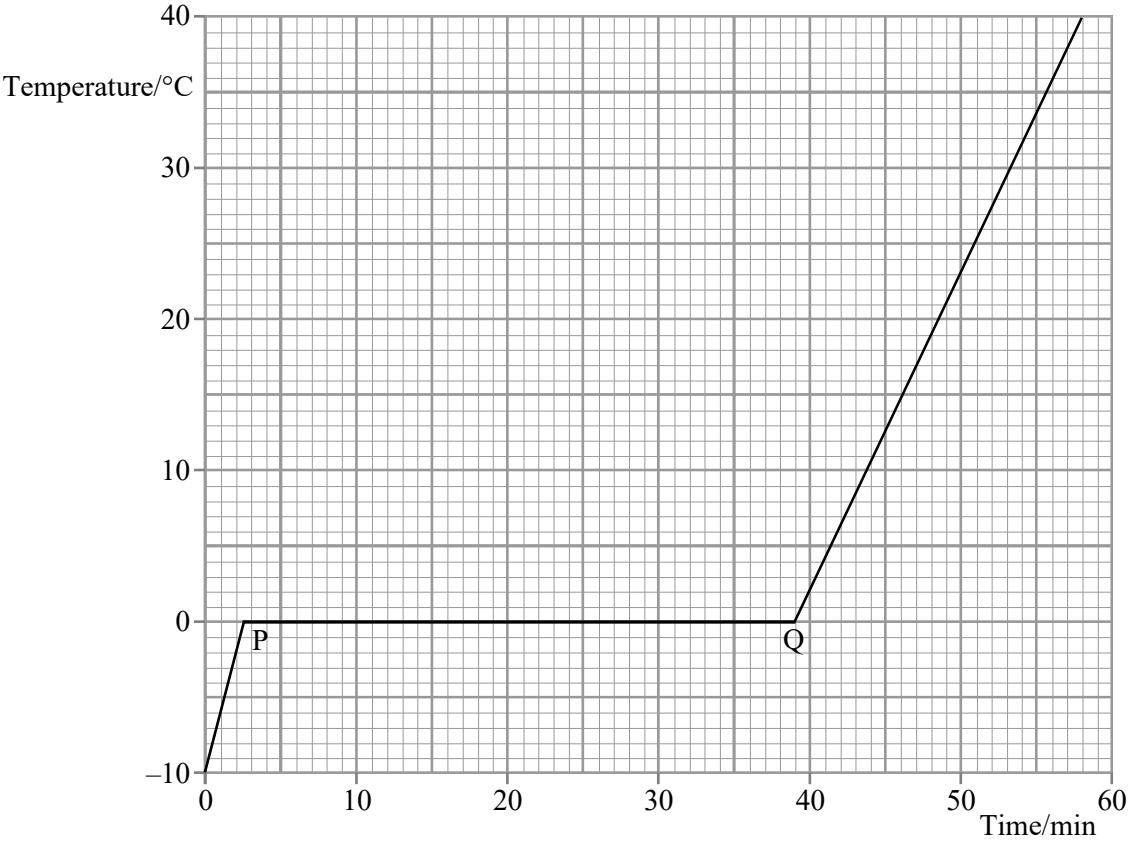
……

Mass =…….....…….....

(4)

(Total 11 marks)

6. A well-insulated vessel contains 0.20 kg of ice at –10 °C. The graph shows how the temperature of the ice would change with time if it were heated at a steady rate of 30 W and the contents were in thermal equilibrium at every stage.



Describe in terms of molecules the change which occurs between points P and Q.

.....

.....

.....

.....

(2)

Use the graph to determine the specific latent heat of fusion of water.

.....

.....

.....

Specific latent heat of fusion .....

(3)

A student tries to plot this graph experimentally. He places crushed ice at –10 °C in a well-insulated beaker containing a small electric heater. What additional equipment would he need, and how should he use it, to obtain the data for his graph?

.....

.....

.....

.....

(2)

Suggest one precaution he should take to try to get an accurate graph.

.....

.....

(1)

Gallium is a metal with a melting point of 29 °C. Its specific heat capacity, in both the solid and liquid state, and its specific latent heat of fusion, are all smaller than those of water. Add to the graph above a second line showing the results you would expect if 0.20 kg of gallium, initially at –10 °C, was heated at the same rate of 30 W.

(3)

(Total 11 marks)

7. You are asked to measure the specific heat capacity of aluminium using a cylindrical block of aluminium which has been drilled out to accept an electrical heater and a thermometer.

Draw a complete diagram of the apparatus you would use.

(3)

List the measurements you would take and explain how you would calculate the specific heat capacity of aluminium from your measurements.

.....

.....

.....

.....

.....

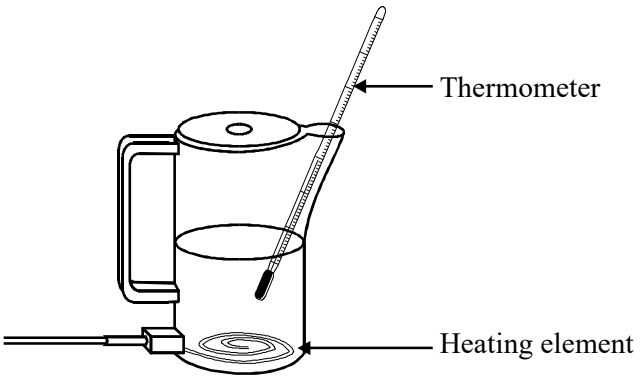
.....

.....

.....

(6)
(Total 9 marks)

8. Water in a plastic kettle is heated by an electric element near the bottom of the kettle. The temperature of the water near its surface can be recorded on a thermometer.



A kettle contains 0.70 kg of water at an initial temperature of 20°C. It is calculated that about 250 kJ of thermal energy is needed to heat the water from 20°C to 100°C. Show how this value is calculated.

(The specific heat capacity of water is 4200 J kg^{-1} K^{-1}.)

.....

.....

.....

(2)

Calculate the time it should take for an element rated at 2.2 kW to supply this energy.

.....

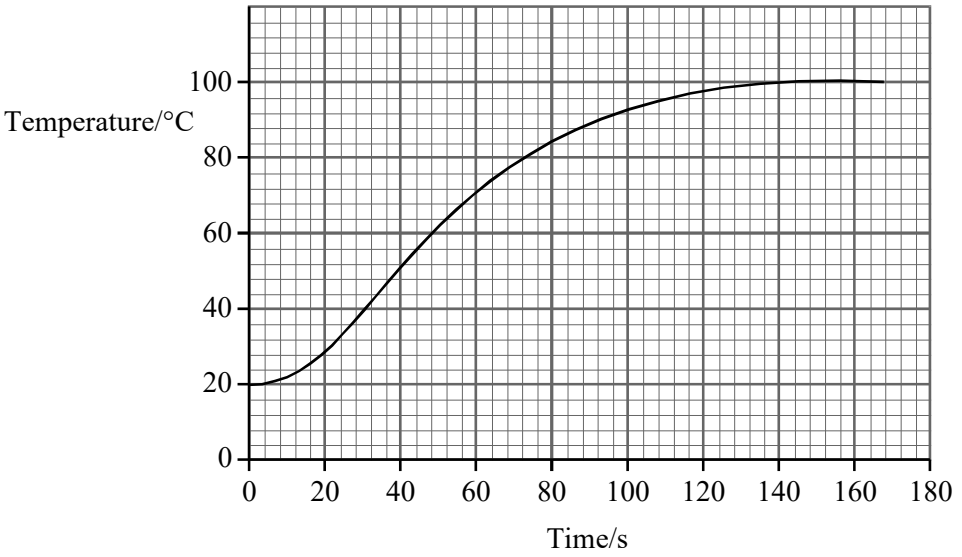
.....

.....

Time = ...

(3)

To check this calculation, the kettle is switched on at $t = 0$ s and temperature readings are taken as the water is heated. The graph shows how the temperature varies with time.



Use the graph to fully describe qualitatively how the temperature of the water changes during the first 160 s.

.....

.....

.....

.....

(3)

Estimate the efficiency of the electric heating element in bringing the water to the boil.

.....

.....

.....

Efficiency = ...

(2)

(Total 10 marks)

9. Define the term **specific latent heat of fusion**.

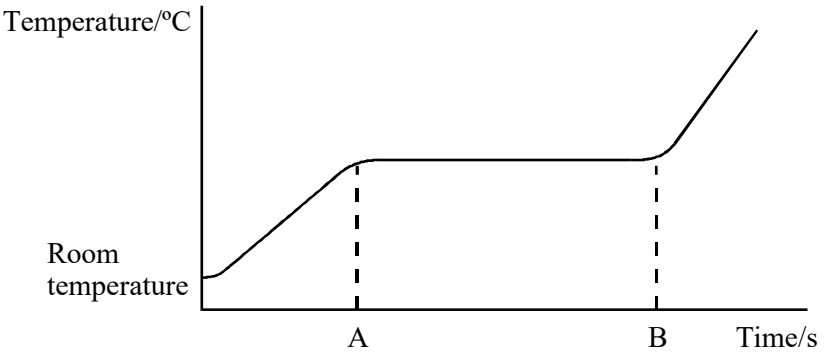
.....

.....

.....

(3)

The graph shows how the temperature of a heated metal sample varies with time.



During the time interval AB, the metal changes from a solid to a liquid whilst still being heated. Explain, in molecular terms, what is happening to the energy being supplied during this time.

.....

.....

(1)

Describe, in molecular terms, the main differences between the solid and liquid states. You may illustrate your answer with simple diagrams.

.....

.....

.....

.....

.....

(2)
(Total 6 marks)

10. Define the term **specific heat capacity**.

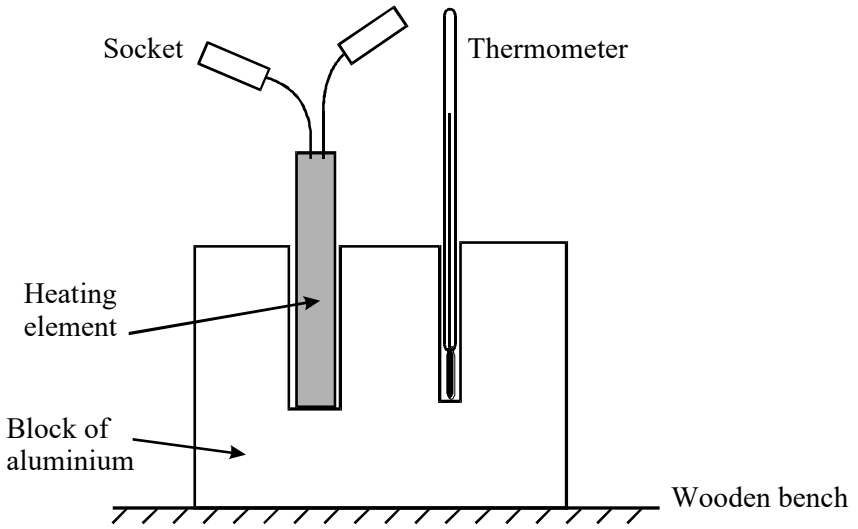
.....

.....

.....

(2)

A student decides to measure the specific heat capacity of aluminium by an electrical method. He selects his apparatus and then assembles the aluminium block, the thermometer and the heating element as shown.



The student intends to substitute his results into the relationship

$$mc\Delta T = VIt$$

Draw a diagram of the electrical circuit he would need to set up in order to be able to carry out the experiment.

(3)

What other pieces of apparatus would he need?

.....

.....

(2)

He carries out the experiment and then calculates his value for the specific heat capacity of aluminium. He discovers that his value is higher than the accepted value of 900 J kg^{-1} K^{-1}.

Suggest why his result is higher than 900 J kg^{-1} K^{-1}.

.....

.....

(1)

With reference to the apparatus shown in the diagram, state two modifications that he should make in order to minimise the discrepancy.

1. .....

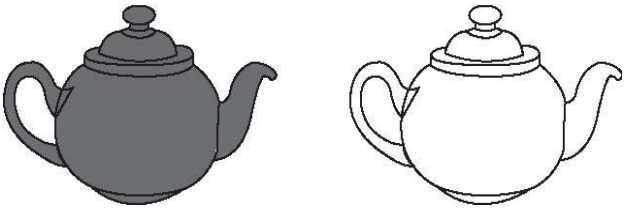
.....

2. .....

.....

(2)
(Total 10 marks)

11. Two metal teapots are identical except that one is black on the outside and the other is white on the outside, as shown below.



The teapots each contain the same amount of hot water.

State and explain which teapot will cool down more quickly.

.....

.....

.....

.....

.....

..... [3]

[Total]

12. Fig. 3.1 shows a thermometer.

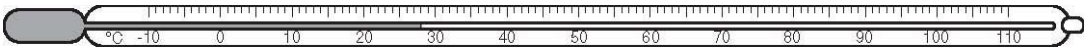


Fig. 3.1

(a) Explain how to calibrate a thermometer.

.....
.....
.....
.....
.....
..... [3]

(b) **(i)** State the range of the thermometer in Fig. 3.1.

..... [1]

(ii) State how you know that the scale of the thermometer in Fig. 3.1 is linear. .....
.....
..... [1]

(c) Fig. 3.2 shows a thermometer which is more sensitive than the thermometer in Fig. 3.1. Only 0 °C is marked on this new thermometer.

On Fig. 3.2, draw the temperature markings for 10 °C and 20 °C. [1]

13 **(a)** State two differences between evaporation of water and boiling of water.

1.....

2. .....[2]

(b) The specific latent heat of vaporisation of water is 2260 kJ / kg. Explain why

this energy is needed to boil water and why the temperature of the water does not change during the boiling.

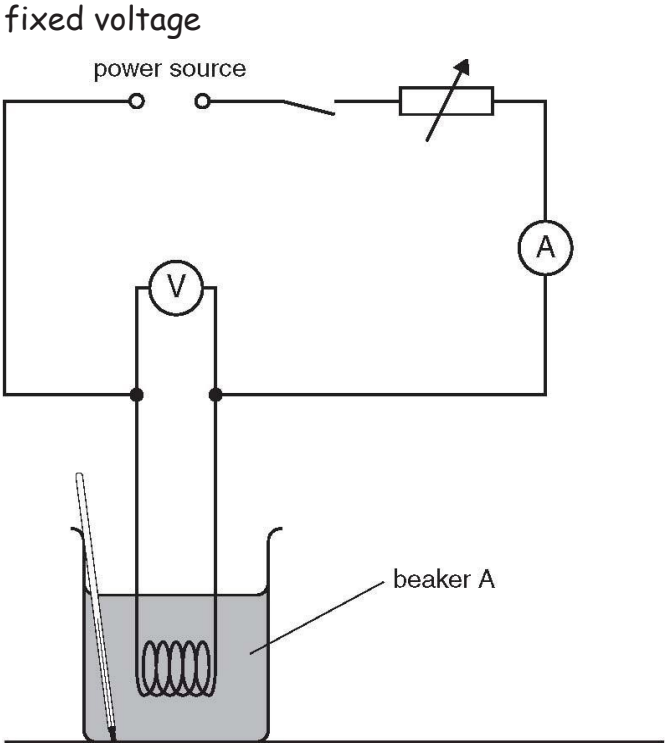
.....
.....
.....
.....[3]

(c) A laboratory determination of the specific latent heat of vaporisation of water uses a 120 W heater to keep water boiling at its boiling point. Water is turned into steam at the rate of 0.050 g / s. Calculate the value of the specific latent heat of vaporisation obtained from this experiment. Show your working.

.....
.....
.....

specific latent heat of vaporisation = ...[3]

14.A form IV student is investigating the temperature rise of water in beakers heated by different methods. The apparatus is shown in Fig. 4.1. Beaker A is heated electrically and beaker B is heated with a Bunsen burner.



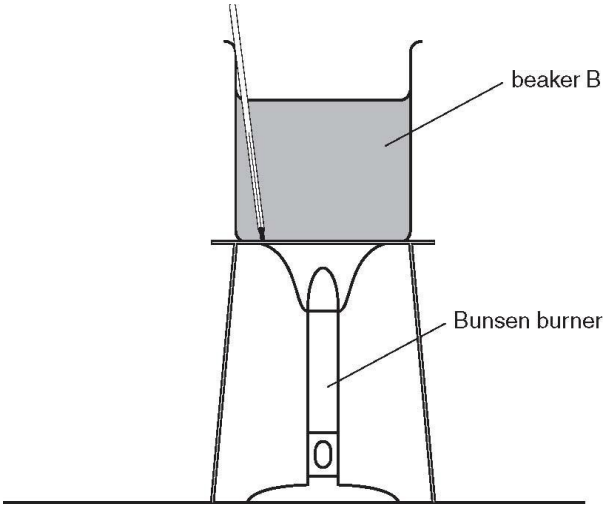


Fig. 4.1

The student first records room temperature.

(a) Fig. 4.2 shows the thermometer at room temperature.

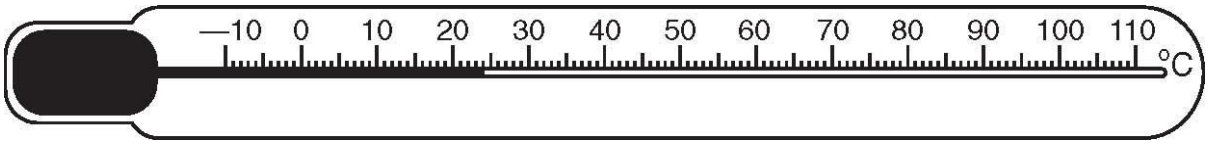


Fig. 4.2

(i) Write down the value of room temperature. room temperature =

..... [1]

(ii) The two beakers are heated from room temperature for the same length of time. The new water temperature for beaker A is 30 °C and for beaker B is 28 °C. Calculate the temperature rise of the water in each beaker.

temperature rise in beaker A = ...

temperature rise in beaker B =

..... [1]

(b) The electrical heater and the Bunsen burner both have the same power and

both beakers were heated from room temperature for the same length of time. Suggest why there is a difference in temperature rise between beaker A and beaker B.

.....

.....

..... [2]

(c) In order to keep the heating effect of the electrical heater constant throughout the heating period, the student adjusts the current. Name the component in the circuit that the student uses for this purpose.

..... [1]