CHRIST CHURCH SECONDARY SCHOOL
2019 PRELIMINARY EXAMINATION
SECONDARY FOUR EXPRESS

CANDIDATE NAME		CLASS	
CENTRE NUMBER	S	INDEX NUMBER	

PHYSICS **6091/02**
Paper 2 Theory
29 August 2019
1 hour 45 minutes

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, index number, name and class on all the work you hand in.
Write in dark blue or black ink.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Section A
Answer **all** questions.

Section B
Answer **all** questions. Question **11** has a choice of parts to answer.

Candidates are reminded that **all** quantitative answers should include appropriate units.
The use of an approved scientific calculator is expected, where appropriate.
Candidates are advised to show all their working in a clear and orderly manner, as more marks are awarded for sound use of Physics than for correct answers.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

This document consists of 25 printed pages including this cover page.
[Turn over

Section A
Answer **all** the questions in this section.

1 A skydiver jumps off the plane and falls through the air before opening up his parachute at a suitable height, h, above the ground. The velocity-time graph of the skydiver is shown in Fig. 1.1.

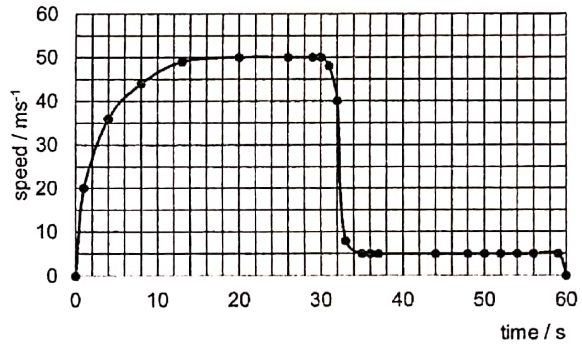


Fig. 1.1

(a) Describe how, and briefly explain why, the air resistance experienced by the skydiver changes

(i) from t = 0 to t = 20 s,

....

....

....[1]

(ii) from t = 20 to t = 30 s.

....

....

....[1]

(b) Estimate the height above the ground, *h*, at which the skydiver opens his parachute.

h = ...[2]

(c) At t = 59 s, the skydiver lands and decelerates sharply upon touching the ground.

Given that the mass of the skydiver and his equipment is 120 kg, calculate the force exerted on the skydiver by the ground.

force = ...[2]

(d) The skydiver later performs the exact same skydive procedures on another planet with no atmosphere and gravitational field strength 10% that of the Earth's.

On Fig. 1.1, sketch the velocity-time graph of the skydiver on this planet. (You may assume that he jumps off at the exact same height, opens the parachute after the same amount of time, and is suitably equipped to survive the harsh conditions on the planet.) [1]

2 The string of a particular bow is pulled back so that, just before the arrow is fired, the archer exerts a force of 320 N on the string, as shown in Fig. 2.1.

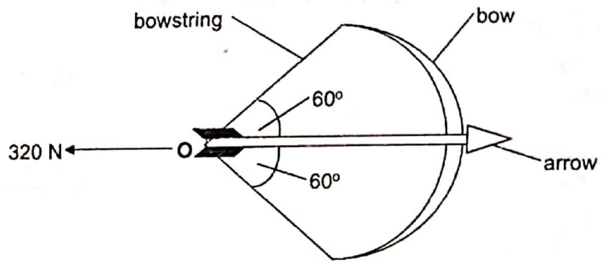


Fig. 2.1

(a) (i) Indicate on Fig. 1.1 the directions of the tension **T** in the two sections of the bowstring at the point **O**. [1]

(ii) Using a scale drawing, determine the magnitude of the tension **T** in the string.

T = ...[3]

(b) The strain energy stored in the bow just before release of the arrow is 120J. When the arrow of mass 175 g is fired, 85% of the strain energy is transferred to the arrow. Calculate

(i) the kinetic energy of the arrow as it leaves the bow,

kinetic energy = ...[1]

(ii) the speed of the arrow as it leaves the bow.

speed = ...[1]

3 (a) Define weight and give an equation for weight.

....

....

.... [2]

(b) A density bottle was used to measure the density of paraffin. The following readings were obtained:

Mass of empty density bottle = 30.20 g
Mass of density bottle filled completely with paraffin = 71.00 g
Mass of density bottle filled completely with water = 82.10 g

Calculate the density of paraffin.

density of paraffin = ...[3]

4 A uniform rod XY of length 80.0 cm and weight 2.0 N is placed on the pivot as shown in Fig. 4.1. A spring balance S is attached to the other end of the rod. A load of 8.0 N is placed 12.0 cm from the spring balance.

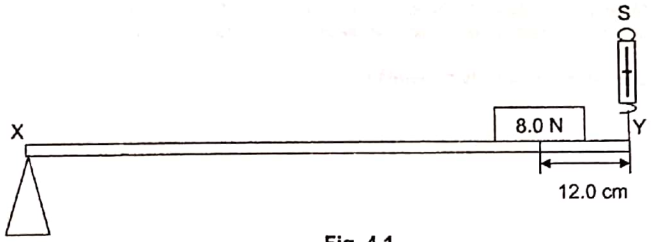


Fig. 4.1

(a) Calculate the reading on the spring balance for the rod to balance horizontally.

reading on spring balance = ...[2]

(b) Determine the magnitude and direction of the reaction (force) on the pivot.

magnitude of reaction force = ...[1]

direction of reaction force = ...[1]

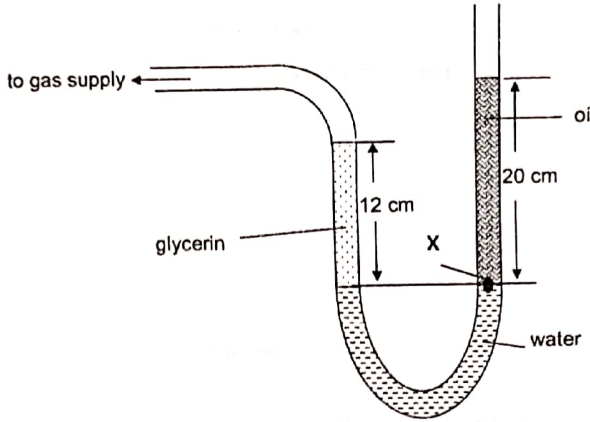
(c) If the 8.0 N weight is gradually moved along the rod towards **X** and the rod is kept horizontal, state and explain the change in the magnitude of **S**.

....

....

.... [2]

5 Fig. 5.1 shows a manometer connected to a gas supply. The manometer is made up three liquids, oil, glycerin and water. It is observed that the level of the liquid in the right arm is higher than that of the left arm.



(a) State the pressure at point **X** in terms of the pressure of the oil and the atmospheric pressure.

.... [1]

(b) Mark Y on the left arm of the manometer, the position at which the pressure is the same as at position X. [1]

(c) Calculate the pressure of the gas.
(Take standard atmospheric pressure to be 1×10^5 Pa, the density of water to be 1.00 gcm^{-3}, the density of the oil to be 0.92 gcm^{-3} and the density of glycerin to be 1.25 gcm^{-3}.)

pressure of the gas = ...[3]

(d) If glycerine is replaced by chloroform, using the value you have calculated in part **(b)**, calculate the height difference between the liquid level in left arm and right arm assuming that the height of the oil remains the same.
(Take the density of chloroform to be 1.49 gcm^{-3})

height difference = ...[2]

6 In a particular experiment, a student suspended a 600 W immersion heater in a beaker of boiling water. He ensured that the heater was completely submerged in the water but did not touch the bottom of the beaker as shown in Fig. 6.1.

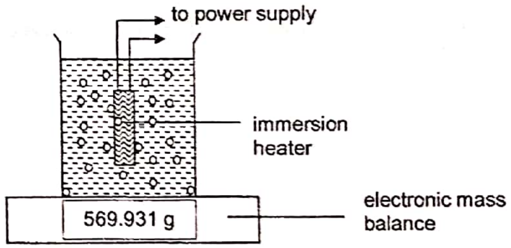


Fig. 6.1

He then placed the beaker with the immersion heater on an electronic mass balance and obtained the following readings:

reading on the mass balance when water started to boil = 569.931 g
reading on the mass balance after water boiled for one minute = 569.016 g

(a) (i) Calculate a value for the specific latent heat of vaporisation of water, l_v.

l_v = ...[1]

(ii) State and explain whether you would expect the answer in part (a)(i) to be an overestimation or underestimation of the actual value of l_v.

....

....

....[1]

(b) Another student doing the same experiment decides to insert a thermometer into the beaker of boiling water at the start of the experiment to be sure that the temperature remains exactly 100 °C throughout the experiment.

(i) Do you think that this student's action made the experiment more accurate? Give your reason.

....

....

....[1]

(ii) The student inserts the thermometer at 30 °C into the boiling water. Given that he uses the same immersion heater and keeps it on for the same duration, use your answer in part (a)(i) to calculate the mass of boiling water that will be boiled off.

(You may take the average heat capacity of the mercury-in-glass thermometer to be 28.5 J K^{-1}, and assume that the thermometer reaches 100 °C before the end of the experiment.)

mass = ...[2]

(iii) Hence explain why thermometers cannot be made of thermometric substances with high heat capacities, like water.

....

....

....[1]

7 Fig. 7.1, which is drawn to full-scale, illustrates the wavefronts of waves travelling from air into another unknown medium. The waves are produced by a vibrating source in the air oscillating at 2.9×10^{10} Hz.

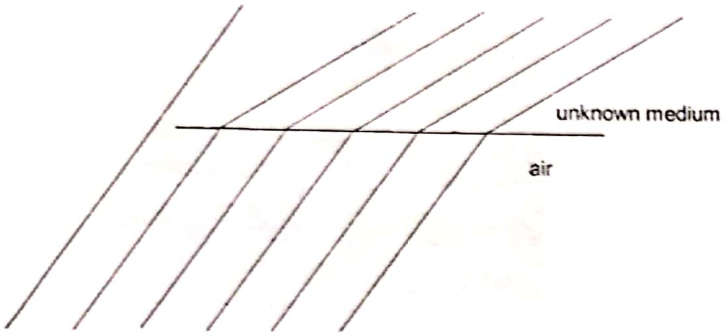


Fig. 7.1

(a) Define the term wavefront.

....

.... [1]

(b) (i) By accurate measurements from Fig. 7.1, determine the wavelength of the waves in air and that in the unknown medium.

wavelength in air = ...[1]

wavelength in unknown medium = ... [1]

(ii) Calculate the wave speed in air and that in the unknown medium.

wave speed in air = ...

wave speed in unknown medium = ... [2]

(iii) Hence, or otherwise, calculate an approximate value for the refractive index of the unknown medium.

refractive index = ... [1]

(c) (i) Explain why the wavefronts could possibly represent an electromagnetic wave.

....

....[1]

(ii) Suggest a possible component of the electromagnetic spectrum that these wavefronts represent and give a use of this type of electromagnetic wave.

....

....[2]

8 Two stages in the production of a photocopy are shown in Fig. 8.1.

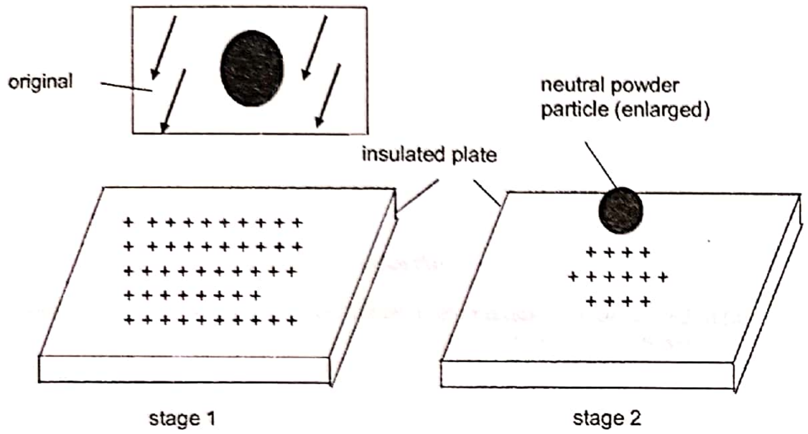


Fig. 8.1

In stage 1, reflected light from the white parts of the original hits the positively charged plate, leaving it as shown in stage 2. Black powder (toner) is then sprayed onto the plate. One neutral powder is shown enlarged in stage 2.

(a) Based on the information provided, state the effect of light on the charged particle.

....

.... [1]

(b) (i) On Fig. 8.1, draw the charge distribution on the neutral powder particle. [1]

(ii) Explain the process by which the charge distribution occurs on the neutral powder particle.

....

.... [2]

Section B (30 marks)

Answer **all** the questions in this section in the spaces provided.
Answer only one of the two alternative questions in **Question 11**.

9

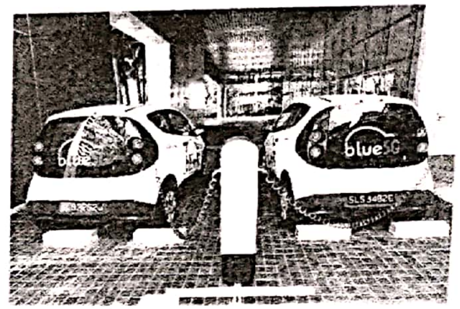


Fig. 9.1

Fig. 9.1 shows two electric cars which looks like ordinary cars on the outside. However, on the inside, electric cars are very different. They are powered by electric motors rather than by gasoline engines.

The electric motor gets its power from an array of rechargeable batteries or fuel cells. The maximum distance that an electric car can travel before it needs recharging depends on the efficiency of its batteries.

There are now several models of commercially available electric cars. Fig. 9.2 shows some information given by the manufacturer of an electric car, undergoing testing.

Mass of car	900 kg
Maximum speed of car	15.0 m/s
Furthest distance travelled by car at maximum speed without recharging.	50.0 km
Average power produced by battery at maximum speed.	2.10 kW
E.m.f of battery	48.0 V
Charging current for the battery	90.0 A

Fig. 9.2

(a) Explain, in terms of forces acting on the car, why the car does not go beyond a maximum speed.

....

....

.... [2]

(b) The car battery discharges to rotate the electric motor to cause the car to move. State the energy changes for this entire discharging process.

....

.... [2]

(c) The car travels the furthest distance of 50.0 km at the maximum speed without recharging.

Calculate the

(i) time taken for the car to travel this distance,

time = ... [1]

(ii) energy provided by the battery,

energy = ... [1]

(iii) efficiency of the battery,

efficiency = ... [2]

(iv) minimum time taken to fully charge the battery of the car.

minimum time = ... [2]

10 Fig. 10.1 shows a transformer.

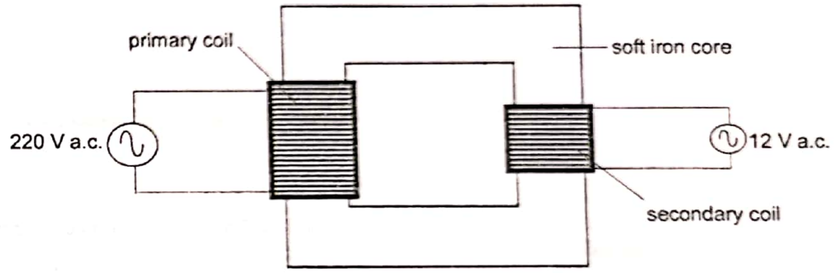


Fig. 10.1

(a) Explain why there is an e.m.f. across the secondary coil even though there is no electrical connection between the primary and secondary coils.

....

....

....

....

....

....

.... [3]

(b) A student wants to test three transformers, P, Q and R. He uses a variable voltage supply to vary the primary voltage and a voltmeter to measure the secondary voltage. The results are as follows in Fig. 10.2

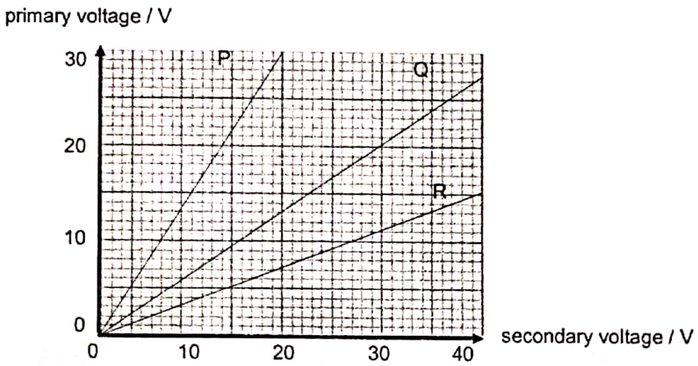


Fig. 10.2

The student wants to connect and iron marked '330 V, 3 300 W' to the mains of voltage 220 V.

(i) State the transformer the student should use.

.... [1]

(ii) Calculate the cost to switch on the iron for 2 hours if it operates at the correct rating. (Given: One kilowatt-hour of electrical energy costs $0.20)

cost = ... [2]

(iii) If the efficiency of the transformer in part **(b)(i)** is 80%, what is the primary current of the transformer?

primary current = ... [2]

(c) The output from the power station generator is connected to a step-up transformer. The transformer is connected to transmission lines.

Explain why a step-up transformer is needed.

....

....

....

.... [2]

EITHER

11 (a) Fig. 11.1 shows a simple electrical circuit of a room and the rating of two appliances. Electricity is drawn from the normal a.c. power supply of 200 V.

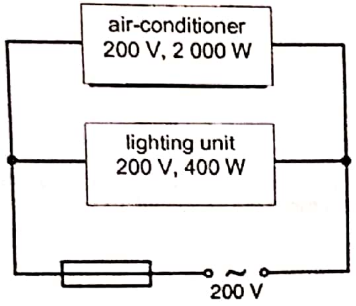


Fig. 11.1

(i) Calculate the total current in the circuit.

total current = ... [2]

(ii) Calculate the cost for four weeks of using the air-conditioner for 8 hours a day and lighting for 6 hours every day if the cost of electricity is $0.25 per kWh.

cost = ... [2]

(b) An electrostatic generator is used to produce sparks, as shown in Fig. 11.2.

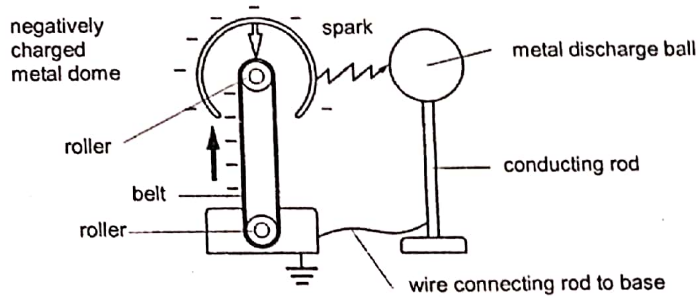


Fig. 11.2

(i) Describe how the belt obtains the negative charges.

....

.... [1]

(ii) Negative charges are carried to the dome. When the discharge ball is brought close to the dome, a spark is produced.

Describe and explain in terms of the movement of negative charges in the discharge ball, how the spark is produced.

....

....

....

.... [2]

(iii) Mark an **X** on Fig. 11.2 to show where there is the most positive charge on the discharge ball. [1]

(iv) When there is a spark, a charge of 1.6 x 10^{-9} C flows in a time of 1.2 ms. Calculate the average current flow in the discharge ball.

current = ... [2]

OR

11 To explore the effects of electricity and magnetism, a student conducted two experiments.

(a) First he pivoted a uniform copper rod, 1 m in length, at its centre of gravity. The ends of the copper rod are connected to a 12 V d.c. supply as shown in Fig. 11.3. A 2 kg mass is suspended on the copper rod 30 cm away from the pivot.

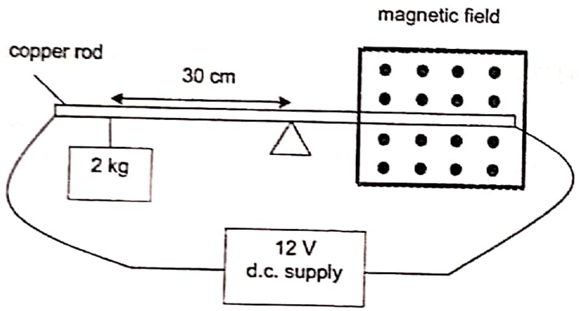


Fig. 11.3

In order to balance the copper rod, the right end of the copper rod is placed within a magnetic field.

(i) State the direction of which the current in the copper rod must flow, in order for the copper rod to be balanced.

.... [1]

(ii) Explain how the current-carrying rod is able to balance the 2 kg mass when the right side is placed in a magnetic field.

....

....

....

....

.... [2]

(iii) Without altering the input voltage of the supply, state and explain one way of increasing the force produced on the right-hand side of the rod.

....

....

....

.... [2]

(iv) A 17 N force is produced on the right-hand side of the copper rod. Calculate the distance from the pivot where this magnetic force is produced. You may take the gravitational field strength to be 10 N/kg.

distance from pivot = ... [2]

(b) Next, the student suspended a loosely-coiled spring from a fixed point, where the ends of the spring are connected to a low voltage supply, as shown in Fig. 11.3.

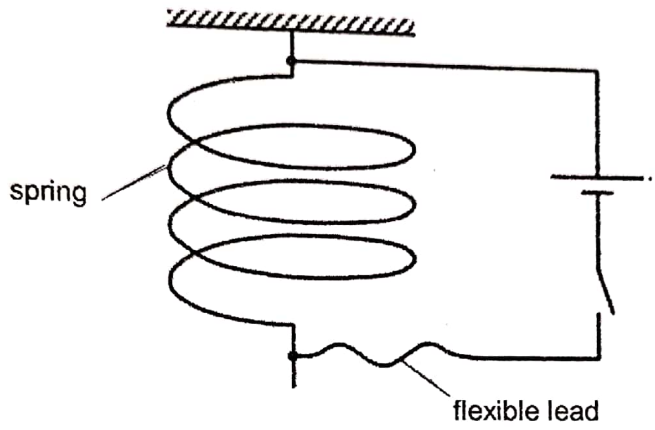


Fig. 11.3

When the current is switched on in the spring, a small change in the length of the spring occurs.

(i) Indicate on Fig. 11.3, the direction of the current in the individual turns of the spring. Label the current I. [1]

(ii) State and explain if the spring will be compressed or extended.

....

....

....

.... [2]

End of Paper

Preliminary Examination 2019
Physics
Secondary 4 Express
Marking Scheme

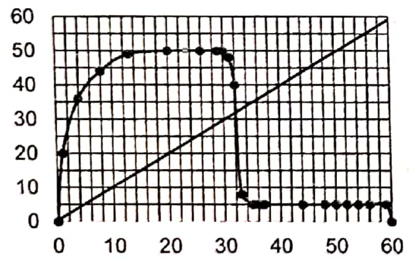
Paper 1 Answers

1	C	2	B	3	A	4	D	5	A	6	C	7	C	8	C	9	A	10	A
11	D	12	B	13	A	14	B	15	C	16	C	17	D	18	B	19	A	20	B
21	D	22	B	23	C	24	D	25	C	26	A	27	D	28	A	29	B	30	B
31	D	32	A	33	A	34	A	35	B	36	A	37	A	38	D	39	B	40	B

Paper 2 Answers

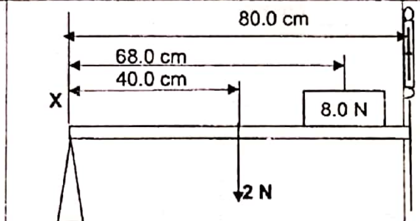
- ½ m throughout for
  - omitted / incorrect units
  - ans not to 2 or 3 sf

Section A

No			Answer	Marks	Remarks
1	(a)	(i)	Air resistance increases as speed increases.	½ ½	
		(ii)	Air resistance remains constant and is equal to the weight.	½ ½	
	(b)		h = area under v-t graph from t = 30 s to 60 s = ½ x (50 + 5) x 4 + 5 x (59 - 35) + ½ x 1 x 10 = **233 m**	½ ½ 1	allow for counting of squares method.
	(c)		F = ma = 120 x 5/1 = 600 N	½ ½ 1	
	(d)		 [10% of 10 = 1m/s² v = u + at = 0 + 1 x 60 = 60 m/s]	1	½ m –straight line ½ m – ends at 60,60.

No			Answer	Marks	Remarks
2	(a)	(i)	2 arrows drawn on string from point **O**.	1	½ mark for each arrow.
		(ii)	Drawing M1 Scale:- 1cm : 50 N (or more) Answer A1 	1 1 1	320 N allow for 5% error: 305 N – 335 N No marks if calculated.
	(b)	(i)	ke = 85 % x 120J = 102 J	½ ½	
		(ii)	½ mv² = 102 J v = 34.1 m/s (to 2 sf)	1 1	allow for ecf

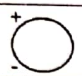
No		Answer	Marks	Remarks
3	(a)	Weight is the force acting on an object due to gravity. Weight = mass x acceleration due to gravity	1 1	
	(b)	Mass of paraffin = 71.00 - 30.20 g = 40.80 g Volume of paraffin = volume of water = mass of water x density = (82.10 – 30.20) x 1.00 g/cm³ = 51.90 cm³ ∴ ρ = m / V = 40.80 g / 51.90 cm³ = 0.79 g /cm³ (to 2 sf)	½ ½ ½ ½ 1	

No	Answer	Marks	Remarks	No
4	(a)		½	½ mark for all distances indicated in dig
		S x 80 = 2 x 40 + 8 x 68 S = 7.8 N	½ 1	
	(b)	upward F = downward F ∴ F_X + 7.8 = 2 + 8 F_X = 2.2 N Upwards	½ ½ ½ ½	
	(c)	Reading on S **decreases**. As 8 N moves towards **X**, **distance from pivot decreases,** hence **clockwise moment decreases** so **anticlockwise moment also decreases** so reading on S decreases as its distance from X remains constant.	1 ½ ½	

No		Answer	Marks	Remarks
5	(a)	$P_X = P_{atm} + P_{oil}$	1	
	(b)	Position of Y is level with X	1	
	(c)	$P_X = P_{gas} + (\rho gh)_{oil}$ $= 1 \times 10^5$ Pa + 920 kg/m³ x 10 m/s² x 0.20 m = 101 840 Pa $P_X = P_{gas} + P_{gly}$ 101 840 Pa = P_{gas} + + 1250 kg/m³ x 10 m/s² x 0.12 P_{gas} = 100 340 Pa	½ ½ ½ ½ 1	
	(d)	$(\rho gh)_{glycerine} = (\rho gh)_{chloroform}$ 1250 kg/m³ x 10 m/s² x 0.12m = 1490 kg/m³ x 10 m/s² x $h_{chloroform}$ ∴ $h_{chloroform}$ = 10.1 cm Hence difference in height = 20.0 – 10.1 = 9.9 cm	 1 1	

No			Answer	Marks	Remarks
6	(a)	(i)	Q = ml_v 600 x 60 = (569.931 – 560.016) l_v l_v = 3630 J/g	½ ½ 1	½ mark for each arrow.
		(ii)	Overestimation A lot of heat lost to surroundings and to beaker were also included in the calculation.	½ ½	
	(b)	(i)	No as the temperature of boiling water remains constant.	½ ½	
		(ii)	Q = $ml_v + C\theta_{thermometer}$ 36 000 = m x 39 344 + 28.5 x 70 m = 9.37 g (to 3 sf)	1 1	allow for ecf
		(iii)	Thermometers with high heat capacities will absorb too much heat causing inaccuracies.		

No			Answer	Marks	Remarks
7	(a)		Wavefront is an imaginary line joining all the points that are in the same phase.	½ ½	
	(b)	(i)	λ_{air} = 1.0 cm λ_{medium} = 0.6 cm	1 1	0 m if -not labelled in dig -not to 1 dp
		(ii)	$v_{air} = f\lambda$ $= 2.9 \times 10^{10} \times 1.0$ $= 2.9 \times 10^{10}$ cm /s $v_{medium} = f\lambda$ $= 2.9 \times 10^{10}$ Hz x 0.6 cm $= 1.7 \times 10^{9}$ cm /s (to 2 sf)	 1 1	
		(iii)	$n_{medium} = v_{air} / v_{medium}$ $= \lambda_{air} / \lambda_{medium}$ = 1.0 cm / 0.6 cm = 1.7 (to 2 sf)	 ½ ½	
	(c)	(i)	The wavefronts are those of transverse waves and EM waves are transverse.		
		(ii)	Radio waves used for communications and broadcasting	1 1	

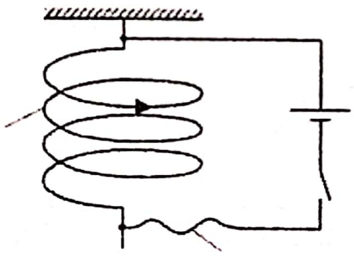
No			Answer	Marks	Remarks
8	(a)		Light causes the particles to discharge / become neutral.	1	
	(b)	(i)		1	
		(ii)	Positive charges on insulated plate attracts electrons in particle as unlike charges attract causing particle to have a net negative charge at the bottom and leaving a net positive charge at the top.	1 1	

Section B

No			Answer	Marks	Remarks
9	(a)		As the car accelerates, the air resistance against the car increases. When the engine force is equal to the resistive forces of friction and air resistance, the resultant force becomes zero. The car will then be traveling at its maximum constant speed.	½ ½ ½ ½	
	(b)		chemical potential energy → electrical energy (battery) (circuit) →kinetic energy + thermal + sound (motor car)	1 1	- ½ m if thermal & sound omitted
	(c)	(i)	t = d / v = 50000 / 15.0 = 3300 s (to 2 sf)	½ ½	
		(ii)	E = P x t = 2100 x 3300 = 7 000 000 J (to 2 sf)	½ ½	
		(iii)	Input P = VI = 48.0 x 90.0 = 4320 W Efficiency = output P / input P x 100% = 2100 / 4320 x 100% = 49 % (to 2 sf)	½ ½ 1	
		(iv)	t = 3300 / 49 % = 6900 s (to 2 s.f.) OR Input E = 7 000 000 J x 100 / 49 = 14 285 714 J t = E/P = 14 285 714 / 2100 = 6800 s (to 2 sf)	½ ½ 1	

No			Answer	Marks	Remarks
10	(a)		Alternating current in the primary coil produces a changing magnetic flux. This changing magnetic flux is linked to the secondary coil via the soft iron core thus inducing an e.m.f. across the secondary coil.	1 1 1	
	(b)	(i)	Q	1	
		(ii)	Cost = 2 x 3.3 x 20 ¢ = $1.32	1 1	
		(iii)	Efficiency = output P / input P x 100% 80% = 3 300 / 220I_P x 100% I_P = 0.053 A (to 2 sf)	1 1	
	(c)		Since P=VI, for the same power when voltage is stepped-up, the current is reduced so I^2R losses are minimised.	1 1	

No			Answer	Marks	Remarks
11E	(a)	(i)	I = P/V = 2000/200 + 400/200 = 10 + 2 = 12 A	½ ½ 1	
		(ii)	Cost = (2 x 8 + 0.4 x 6)28 x $0.25 = $129 (to 3 sf)	1 1	
	(b)	(i)	Friction between belt and pulley / roller causes electrons to move to the belt (charging by friction)	1	
		(ii)	Negative charges in discharge ball move further from the dome since like charges repel Net positive charges electric discharge ball closest to dome creates an **electric field** between dome and discharge ball / attracts negative charges producing sparks.	1 1	
		(iii)	**X** is at end of spark in ball.	1	
		(iv)	I = Q/t = 1.6×10^{-9} C / 0.0012 s = 1.3×10^{-6} A	½ ½ 1	

No			Answer	Marks	Remarks
110	(a)	(i)	Left to right.	1	
		(ii)	The interaction of the magnetic field due to the current in the rod and the external magnetic field, induces a force.	½	
			The direction of the force can be found from Fleming's LHR,	½	
			which states that when the fingers of left hand are stretched with first finger pointing in the direction of the magnetic field (out of page) and the second finger in the direction of the current (right), the thumb will point in the direction of the force / thrust (downwards)	½	
			which produces a clockwise moment to balance the 2 kg mass.	½	
		(iii)	Increase magnetic field strength. Greater force is induced with a stronger magnetic field.	1 1	
		(iv)	17 x d = 20 x 30 d = 35 cm (to 2 sf)	1 1	
	(b)	(i)		1	
		(ii)	Slightly compressed as unlike poles induced in each individual coil will attract each other.	1 1	

End