Hermitage Academy

Physics Department

Higher Physics Homework

1. (a) Classify these quantities into those that are **scalars** and those that are **vectors**:

distance **speed** **displacement**

time **velocity** **acceleration** 2

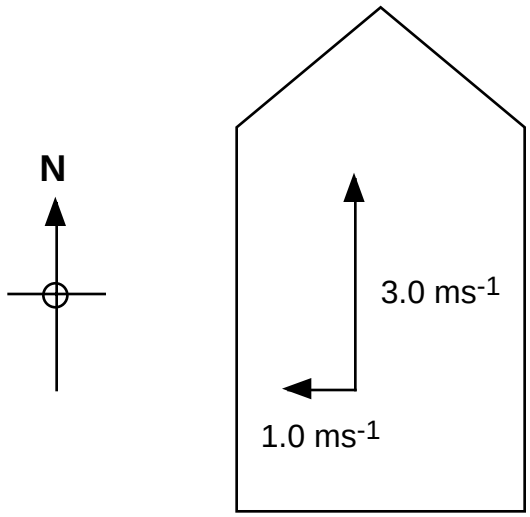
(b) What is the **difference** between a scalar quantity and a vector quantity? 1

2. A car travels due East (bearing 090^0) from point **A** for 6.0 km to point **B** and then North-west (bearing 315^0) for 4.0 km to point **C**.

(a) How **far** has the car travelled? 1

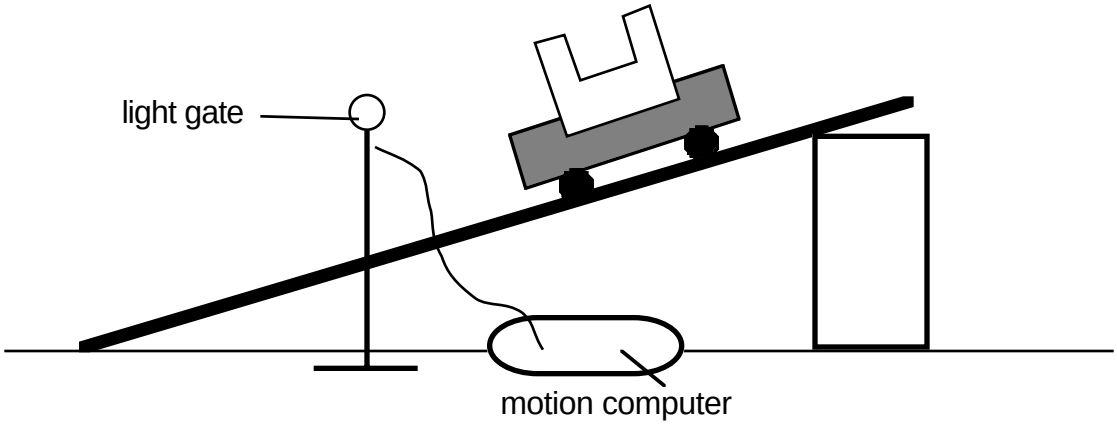
(b) By constructing a vector diagram, or otherwise, find the **resultant displacement** (magnitude and direction) of the car at point **C** from point **A**. 3

3. A ship is sailing due North (bearing 000^0) in a harbour at 3.0 ms^{-1}. A man jogs across the deck at 1.0 ms^{-1} in a westerly direction (bearing 270^0).



Find, by vector diagram or otherwise, the **velocity** (magnitude and direction) of the man relative to the land. 3

4. A trolley runs down a slope. A 'double' mask on the trolley cuts through the beam of a light gate. The light gate is connected to the input of a motion computer.



State what the system actually **measures** and any **extra** measurement(s) which has to be programmed into the computer. Explain **fully** how the computer is able to calculate the acceleration of the trolley. 4

5. A car is travelling at a velocity of 12 m/s in a straight line. It accelerates to overtake another car at a rate of 2.0 m/s^2 for 3.0 s.

(a) What is the car's **change** of velocity due to the acceleration? 2

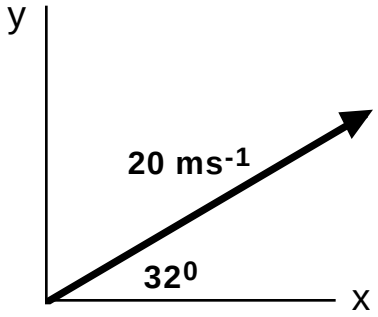
(b) Calculate the **final** velocity of the car. 1

6. A train is travelling at 60 ms^{-1} along a straight section of track when it passes a red signal and decelerates at a uniform rate of 6.0 ms^{-2}.

(a) How **long** does the train take to come to a halt? 2

(b) How **far** after the signal does it stop? 2

7. Use trigonometry to find the horizontal (x) and vertical (y) **components** of this velocity vector. 2



8. A parachutist falls at a constant speed of 4.0 ms^{-1} from a height of 100 m through a crosswind of speed 2.0 ms^{-1}. How long will it take her to reach the ground? 2

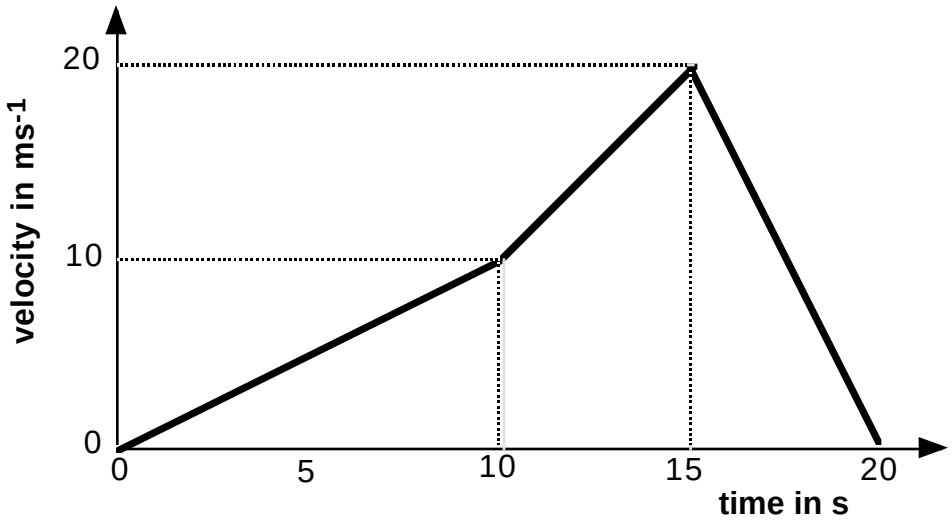
Total = 25

[Graph paper needed]

1. (a) What **quantity** can be calculated from the **area** under a
   (i) speed-time graph (ii) velocity-time graph
   (iii) acceleration - time graph? $1^1/_2$

   (b) What **quantity** is given by the **gradient** of a velocity-time graph? $^1/_2$

2. Below is a velocity-time graph for the motion of a car over 20 seconds. The car is travelling in a straight line.



   (a) Calculate the **displacement** of the car over 20 s. 2

   (b) Calculate the car's **average velocity** over the whole motion. 2

   (c) On **graph paper**, construct the **acceleration-time** graph for the whole motion. 2

   (d) **Show** that the total area under the acceleration-time graph is zero. Explain the *significance* of that result. 3

3. A pupil made a number of measurements of the acceleration of a dynamics trolley running down a steep slope.

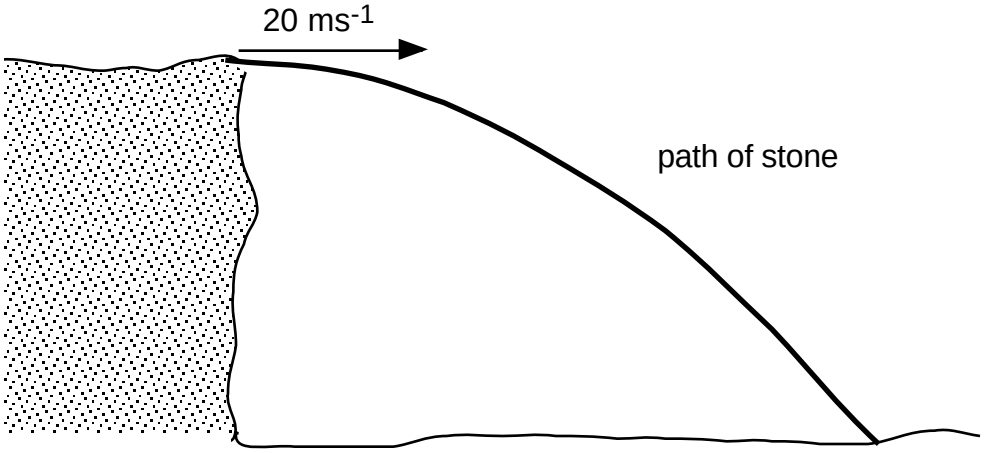
3.4 ms^{-2}	**3.7 ms^{-2}**	**3.5 ms^{-2}**	**3.4 ms^{-2}**
3.5 ms^{-2}	**3.6 ms^{-2}**	**3.9 ms^{-2}**	**3.3 ms^{-2}**

(a) Calculate the **average** of the measurement to 3 significant figures. 1

(b) Calculate the **approximate random uncertainty** in the measurements. 1

(c) What is the **percentage uncertainty** in the best estimate of the acceleration? 1

4. A stone is thrown from the edge of a cliff with a horizontal velocity of 20 ms^{-1}.



(a) What is the stone's **horizontal** velocity 3.0 s later? 1

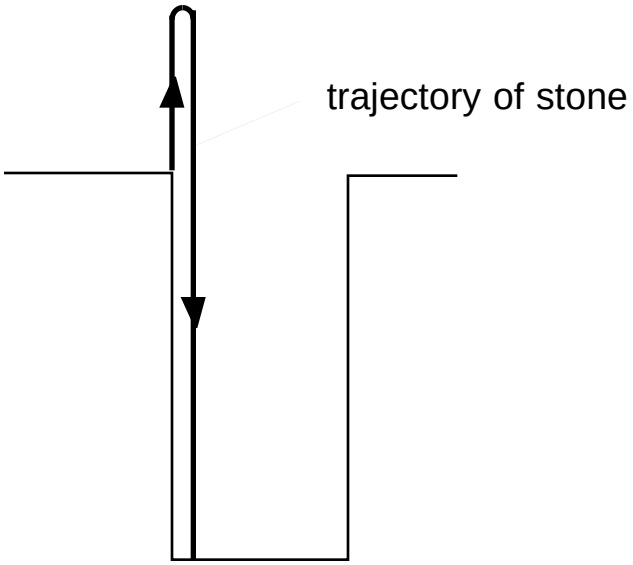
(b) What is the stone's **vertical** velocity 3.0 s later? ['g' = 9.8 ms^{-2}]. 1

(c) Calculate the stone's actual **velocity** (magnitude and direction) after 3.0 s. 2

(d) If the stone takes 4.5 seconds to reach the bottom of the cliff, what is its height? 2

(e) How **far** from the foot of the cliff does the stone land? 1

5. A girl throws a coin straight up at a speed of15 ms^{-1} from the edge of a well. She sees the coin splash into the water at the bottom 5.0 seconds later.

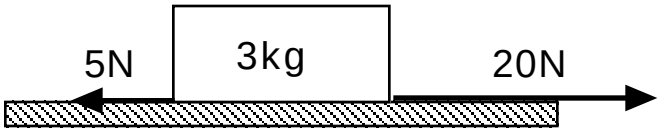


(a) How **deep** is the well? ['g' = 9.8 ms^{-2}]. 2

(b) How **high** above the well's edge did the coin reach? 2

Total = 25

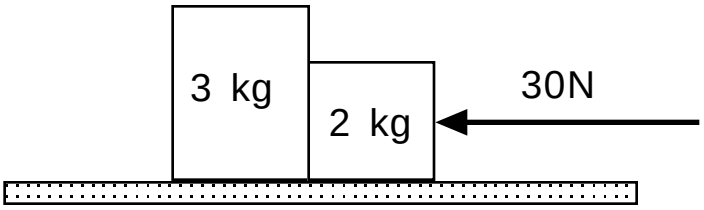
1. A 3 kg mass, resting on a level surface is pulled to the right by a force of 20N. There is 5N of friction between the mass and the surface.



(a) What is the magnitude and direction of the **unbalanced** force force on the mass? 1

(b) Calculate the magnitude of the **acceleration** of the mass. 1

2. Two blocks, masses 2 kg and 3 kg, are resting on a *frictionless* surface. They are pushed by a force of 30N as shown.

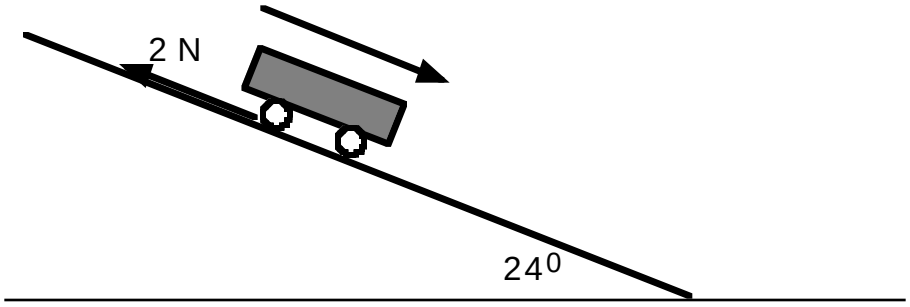


(a) What is the magnitude of the blocks' **acceleration**? 2

(b) What is the **magnitude** and **direction** of the unbalanced force on the *3 kg* block? 2

(c) With what **force** does the 3 kg block push on the 2 kg block? Explain your answer. 2

3. A trolley is running down a slope which makes an angle of 24**°** with the horizontal. The trolley's mass is 2 kg. There is a constant frictional force 2N acting on the trolley, up the slope.



(a) Calculate the trolley's **weight**. [g = 9.8 Nkg^{-1}] 1

(b) Calculate the **component** of the weight parallel to the slope. (Answer to 2 significant figures). 1

(c) Calculate the **unbalanced force** on the trolley parallel to the slope and hence find its **acceleration**. 3

3. (d) Describe how you would use a mask, light gate and motion computer to measure the **instantaneous speed** of the trolley at the bottom of the slope. (Specify what the computer measures, what it calculates and what has to be programmed into its memory). 3

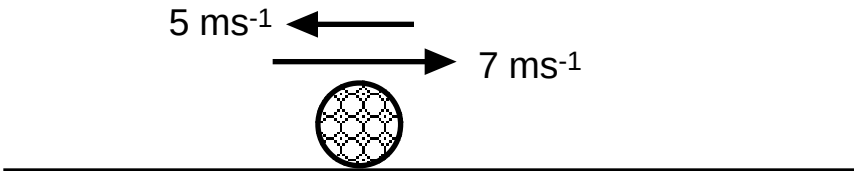
4. A boy, whose mass is 60 kg, runs up a flight of stairs which is 5.0 metres high in a time of 6.0 seconds.

By considering how much work he has to against the force of gravity (that is, how much potential energy he gains), calculate the average **power** developed by his legs. 3

5. During a football match, a player kicks the ball back along the direction from which it came, increasing its *speed* from 5 ms^{-1} to 7 ms^{-1}.

The time of contact between foot and ball is 50 milliseconds.

The ball's mass is 600 g.



(a) What is the **change of velocity** of the ball due to the kick? 1

(b) What is the ball's **change of momentum**? 1

(c) Calculate the **average force** exerted on the ball during the kick. 2

(d) Sketch the likely shape of the **force-time** graph for the kick. No numerical values are required. 1

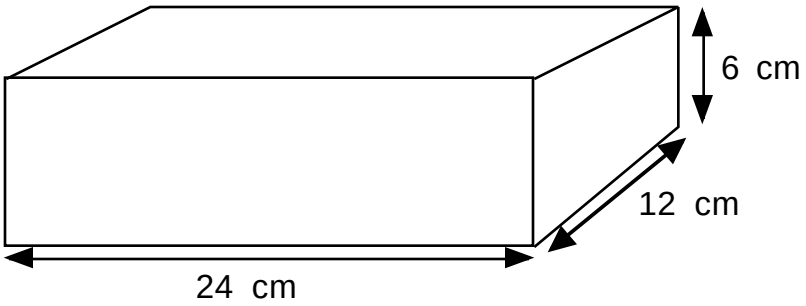
(e) State which **quantity** is given by the area under a force-time graph. 1

Total = 25

[Graph paper needed]

1. A lump of nickel with a mass of 267 grams has a volume of 30 cm^3. Calculate nickel's **density** in kgm^{-3}. 2

2. A brick has dimensions of 24 cm x 12 cm x 6 cm. It weighs 40 N.



By considering the **areas** of the brick's faces, calculate the ***largest*** **pressure** which it can exert on when resting on a flat surface. Answer in **pascals**. 3

3. Sea water has a density of 1020 kgm^{-3}.
   (a) What is the **pressure** due to the water at a depth of 15 m? 2
   (b) What would the inward **force** due to water pressure be on the window of a submersible craft if the window's area measures 0.6 m^2? 2

4. A ship sinks deeper into the water as it sails upriver from salt water to fresh water. **Explain** why this happens in terms of upthrust, density and pressure. 2

5. Convert these **Celsius** temperatures into **kelvin**:
   (a) 0°C (b) 37°C (c) 273°C (d) -176°C 2

6. A gas trapped in a *rigid* container is at a pressure of 1.4×10^5 Pa when its temperature is 20°C. Calculate its **pressure** at 60°C. 2

7. The volume of a fixed mass of gas at a constant temperature is measured at different pressures. The measured data is in the table below:

Pressure (units)	1	2	3	4	5	6
Volume (cm^3)	60.0	29.4	20.1	15.0	11.8	9.9

Graphically, or otherwise, determine the **relationship** between pressure and volume. [Note: only a straight line graph through the origin will allow the relationship to be stated.] 3

8. The gas in a flexible container has a volume of 4.6 m^3 when the pressure is 2.0 x 10^5 Pa. If its temperature remains constant, what will its **volume** be if the pressure is increased to 3.0 x 10^5 Pa? 2

9. **Explain**, in terms of the kinetic theory of gases, why the pressure of a fixed mass of gas increases when it gets hotter. 3

10. State the value of **absolute zero** in Celsius degrees.
Why is so-called? 2

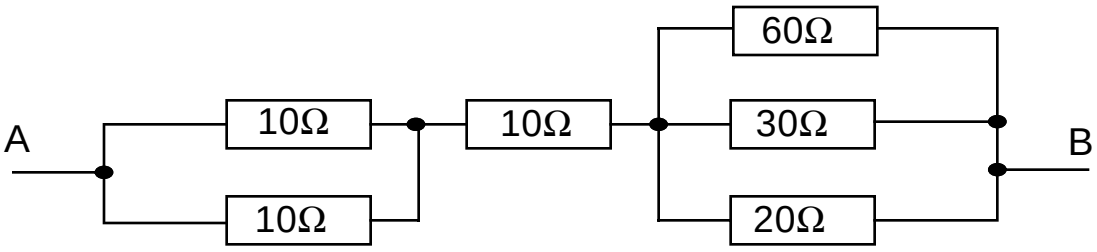
Total = 25

1. A typical lightning strike delivers a charge of 20 coulombs in 1 millisecond across a potential difference of 50 megavolts.

   (a) Calculate the average **current** during the lightning strike. 2

   (b) How much **energy** is released by the strike? 2

2. (a) Calculate the **total resistance** of this network of resistors between **A** and **B**, showing your working: 2



   (b) A potential difference of 25 volts is connected across **AB**.

   Calculate:

   (i) the **voltage** across the ***30Ω*** resistor and

   (ii) the **current** through the ***20Ω*** resistor. 3

3. (a) State what is meant by the **potential difference** between two points in an electric field. 1

   (b) In an electron gun, an electron is accelerated from rest across the electric field between two electrodes. There is a potential difference of 2.5 kV across the electrodes.

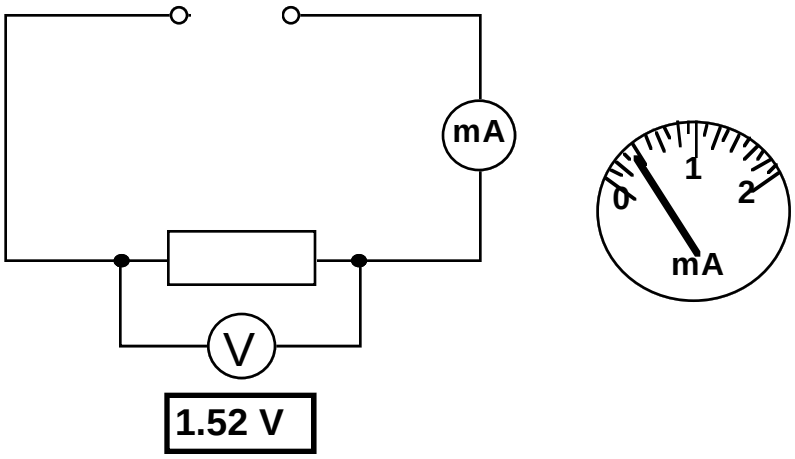
   (i) Calculate the **work done** by the field on the electron. [Electron's charge, *'e'*, = 1.6×10^{-19}C]. 2

   (ii) What kind of **energy** does the electron gain as a result of the work done by the field? 1

   (iii) Calculate the maximum **speed** reached by the electron. [Electron's mass, *'m'* = 9.1×10^{-31}kg]. 2

4. A packet of carbon resistors is unlabelled. A pupil wants to know what value the resistors have but she doesn't know how to use the colour coding.

She connects one of the resistors to a power supply and measures the current and voltage as shown below.



(a) The readings on the *digital* voltmeter and the *analogue* milliammeter are as shown in the diagram above.

(i) Write down each **reading** including its **absolute** uncertainty.

(ii) Calculate the **percentage** uncertainty of each reading.

(iii) Calculate the **best** estimate of the resistance of the resistor and its ***absolute*** uncertainty* and present the answer in the form:

resistance = (final value $^{+}$/- uncertainty)Ω 7

(b) The resistance of each of the resistors in another unlabelled packet measured with an ohmmeter. The measurements are:

65Ω 61Ω 73Ω 64Ω 59Ω 62Ω

Calculate the **best** estimate of the resistance value which should be labelled on the packet and its **random uncertainty***. 3

Total = 25

***** Note: it is usual to give the *final* uncertainty as **1 significant** figure (unless it *itself* would be '**1**' or '**2**' in which case **2** significant figures should be used). The best estimate figure should be rounded to match the uncertainty.

Higher Physics **Electricity and Electronics - Homework 2**

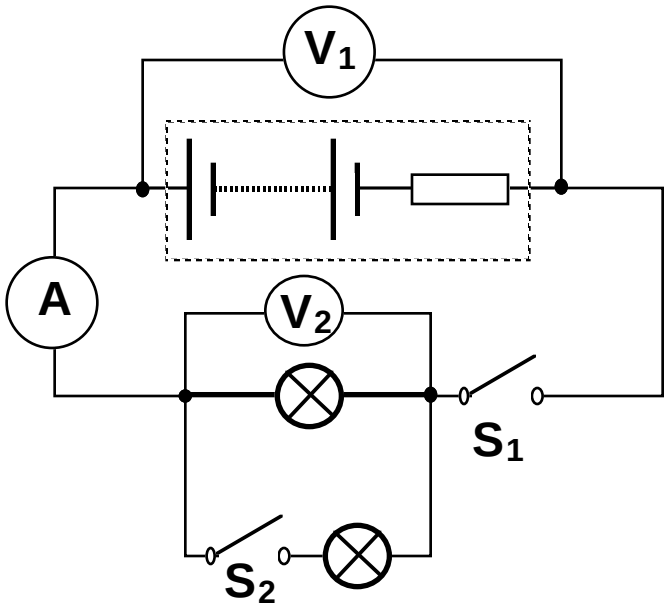
1. (a) What do the letters '**e.m.f.**' stand for in relation to a power supply? 1

   (b) Copy and complete this definition of e.m.f:

   "the e.m.f. of a _____ is the electrical _____ _____

   supplied to each unit of _____ passing through the source." 2

2. A battery has an e.m.f. of 9.4 volts is used as a power supply in a circuit with low power lamps.



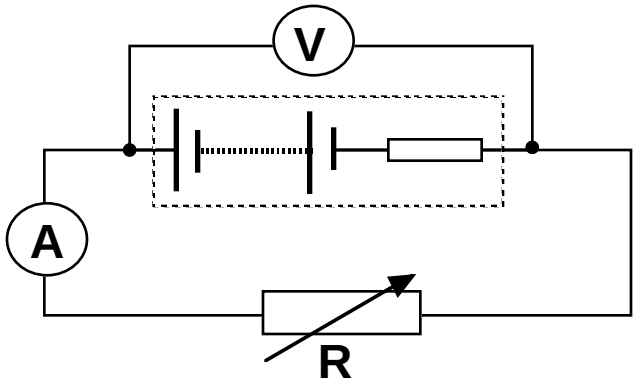
   (a) With the switch 1 and 2 both **open**, what would be the readings on the ammeter and each voltmeter?

   Present the figures in a table with appropriate headings. 2

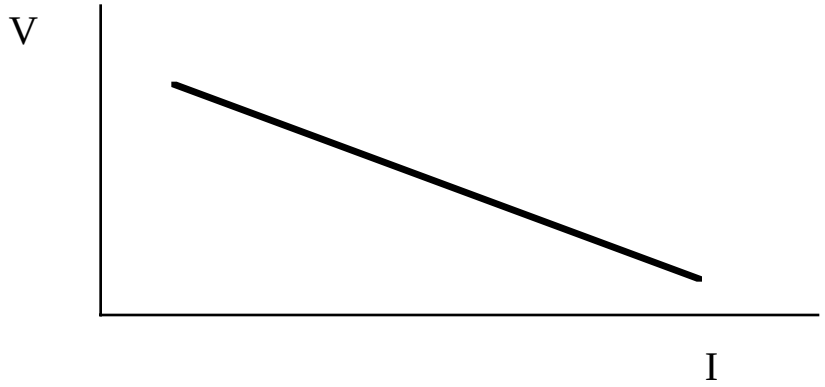
   (b) Switch 1 is now closed, lighting one of the lamps. The reading on $\mathbf{V_1}$ is now 6.6 volts whilst the ammeter reads 0.30 amps.
   Calculate the **internal resistance** of the battery. 2

   (c) Switch 2 is now closed. Assuming that the lamps are identical and that each lamp's resistance does **not** change with temperature, calculate the new reading on each meter. Tabulate the figures. 3

3. Readings of voltage and current are taken for different settings of the variable load resistor in the circuit below.



(a) A graph of voltage against current is drawn.



There are no values on the axes, but, if there were, describe how you would use such a graph to estimate :

(i) the **e.m.f.** of the battery and (ii) its **internal resistance** 2

(b) (i) Show that the following relationship is true for the above circuit:

$$\mathbf{R = \frac{E}{I} - r}$$

where 'R' is the load resistance, 'r' the internal resistance, 'E' the e.m.f. and 'I' the load current. 2

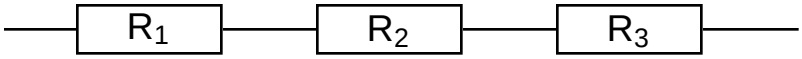
(ii) Sketch the **graph** which would be obtained by plotting 'R' against '$^1/_I$'. 2

(iii) Which **quantities** would be obtained from the above graph from

A. the intercept on the 'R' axis and

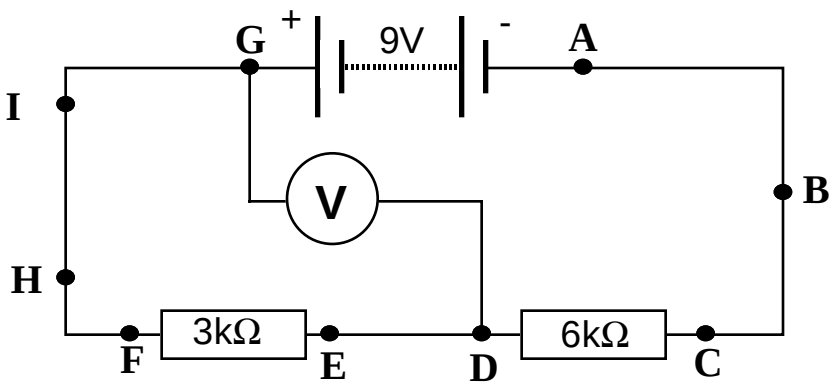
B. the gradient? 2

4. By considering the conservation of energy, derive the expression for the **total resistance** of three resistors, R_1, R_2 and R_3, in series. 2



5. (a) Explain the difference between the terms 'potential' and 'voltage'. 1

(b) In the circuit below, assume that the battery has negligible internal resistance.



(i) Calculate the voltage (or potential difference) across the 6kΩ resistor. 1

(ii) Which of these pairs represent points in the circuit which **do not** have the same potential?

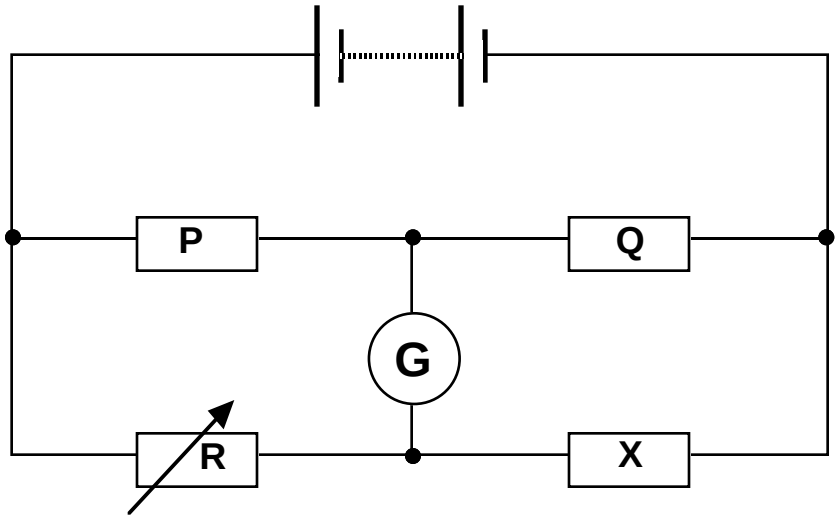
AB **DE** **FH** **IG** **GA** 1

(iii) State and explain the **reading** on a voltmeter connected between points **H** and **I**. 1

(iv) What would be the reading on the voltmeter connected as shown in the circuit? 1

Total = 25

1. In the following circuit, the resistors **P** and **Q** are fixed resistors of known values. Resistor **R** is a resistance box. The value of resistor **X** is not known. Meter **G** is a sensitive ammeter, called a galvanometer.



(a) In order to find a value for resistor **X**, the circuit has to be *balanced*. Describe how this is done. 1

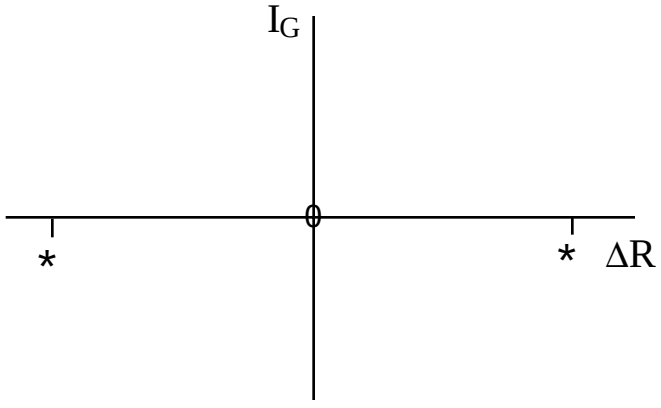
(b) For one resistor, **X**, the circuit was balanced with the following resistance values:

P - 600Ω **Q** - 900Ω **R** - 644Ω

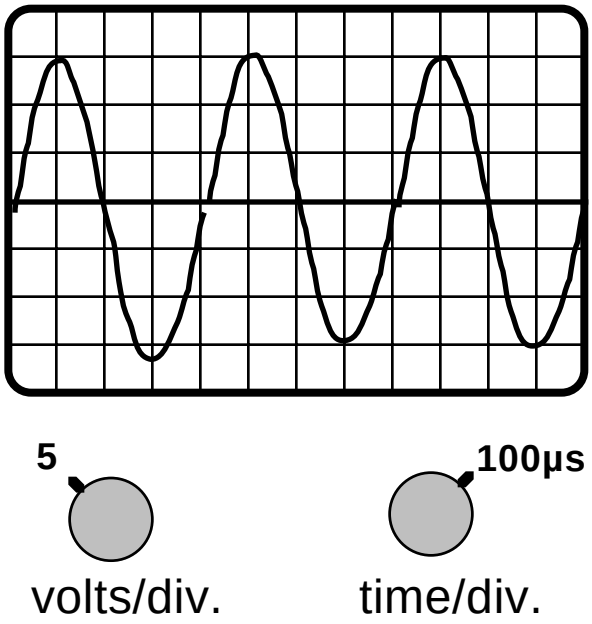
Calculate the value of the resistance of resistor **X**. 2

(c) What **name** is usually used for the circuit? 1

(d) Starting from the balance setting, the value of **R** is now altered through the range 634Ω to 654Ω. Readings, I_G, are taken from the meter for a number of values of **R** and a graph constructed. Copy and complete the graph to show its likely **shape** and the two missing numbers at * on the x-axis. 2



2. An output from a signal generator was connected to the y-inputs of an oscilloscope. The following trace appeared on the screen.



(a) Use the time-base setting shown to calculate:

(i) the **period** of a cycle and

(ii) the **frequency** of the signal displayed. 3

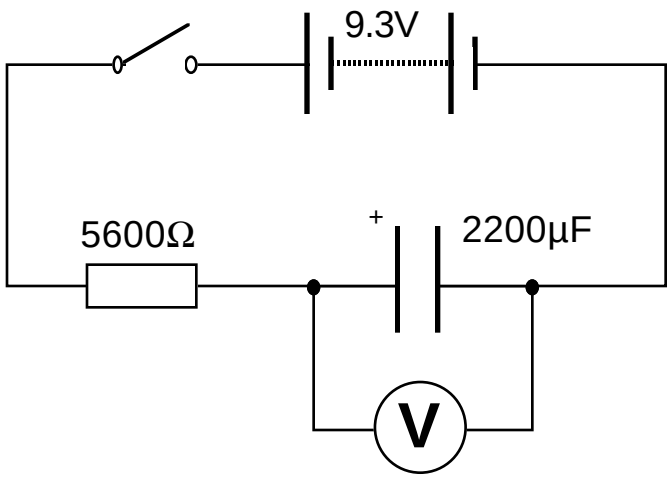
(b) (i) Calculate the **peak** value of the signal's voltage, using the setting of the oscilloscope's y-gain control. 2

(ii) Estimate the **scale reading uncertainty** in the number of divisions measured. 1

(c) Calculate the **root mean square** (r.m.s.) value of the signal's voltage. Quote the value correct to **two** significant figures. 2

(d) Copy the oscilloscope 'screen' grid. Sketch the **appearance** of the *same* signal if the settings of the y-gain and time-base controls were altered to 10 volts/div. and 50µs/div. respectively. 2

3. A capacitor and resistor are connected in series as shown in the circuit diagram.



The capacitor, initially uncharged, is charged from the 9.3 volt battery on closing the switch. After a few seconds, the voltage across the capacitor is 5.4 V.

(a) What is the **voltage** across the resistor at the moment when the capacitor voltage is 5.4 V? 1

(b) Calculate the **charging current** at that same instant. 2

(c) Calculate the **charge** on the plates of the capacitor at that instant. 2

(d) How much **energy** does the capacitor store when *fully* charged? 2

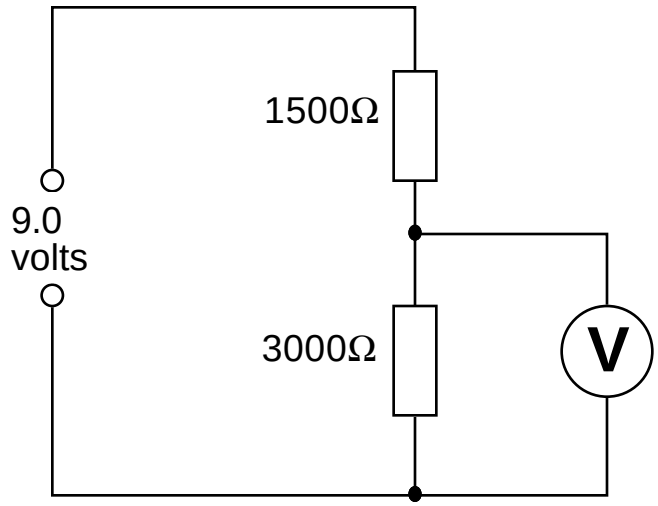
(e) The voltage across the capacitor was noted every second for the time it took to fully charge the capacitor. A graph of capacitor voltage 'V_c' against time 't' was drawn. Sketch the likely **shape** of the graph.
[No values are needed so the graph can be sketched on blank paper]. 1

(f) Using the *same* axes, sketch a possible graph for repeating the procedure with the *same* capacitor but a *smaller* value of resistor. 1

[Quote all answers correct to two significant figures.]

Total = 25

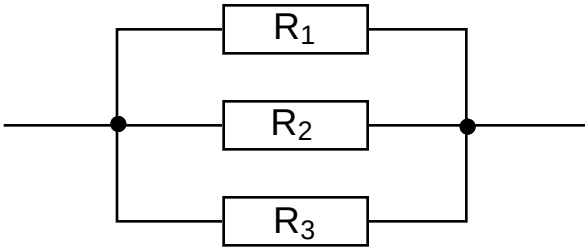
1. A voltage divider consists on two resistors connected in series across a 9.0 volt power supply.



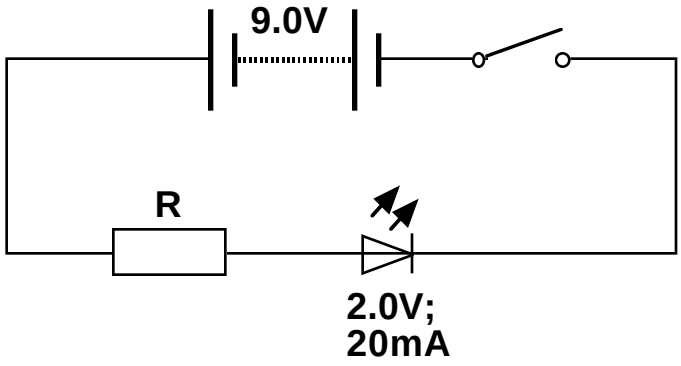
(a) **Show** that the voltmeter reads 6.0 volts. 2

(b) A 230V lamp which has a filament resistance of around 10Ω is now connected in parallel the 3000Ω resistor. However, the lamp fails to light and tests reveal it is *not* faulty.
Explain why the lamp fails to light. 2

2. By considering the conservation of charge, derive the expression for the **total resistance** of three resistors, R_1, R_2 and R_3, in parallel. 2



3. A light emitting diode (LED) is rated at 2.0V; 20mA. It is to be powered by a 9.0V battery. Calculate the **resistance** of the series resistor, R. 3



4. (a) For an ***ideal*** op-amp, what is assumed about each of the following:

(i) the input **resistance**,

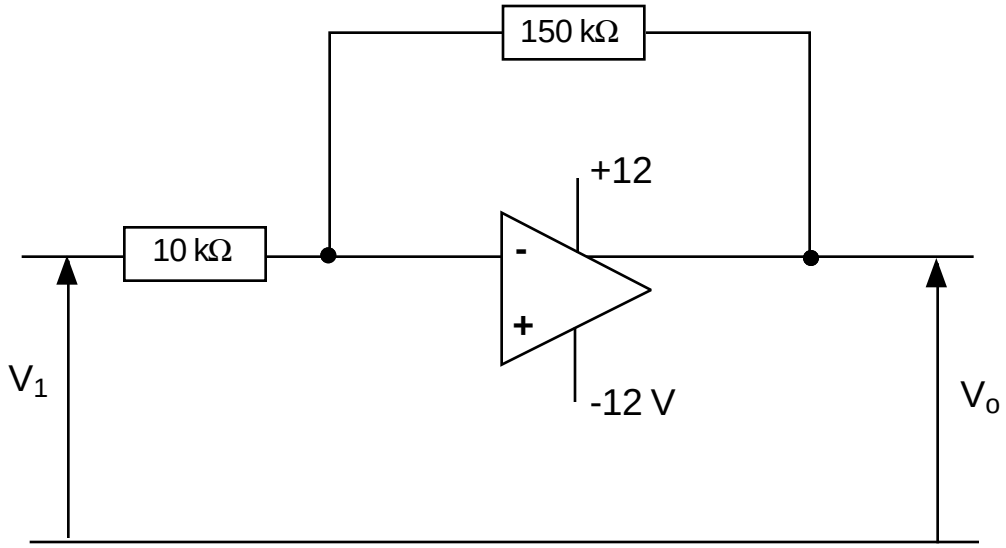
(ii) the input **current** and

(iii) the **p.d.** between the inverting and non-inverting inputs? 3

(b) (i) State the **gain** expression for an op-amp used in the **inverting mode**. 1

(ii) In the equation for calculating the output voltage, what is the significance of the '**-**' sign? 1

(c) An op-amp is set up in the inverting mode with an input resistor of 10 kΩ and a feedback resistor of 150 kΩ. Its power supply is 12-0-12 volts.



Calculate the value of the output voltage, 'V_o', when the input voltage, 'V_1', is:

(i) 0.50 V (ii) - 0.20 V (iii) 1.4 V 6

(d) The feedback resistor is changed to another value such that when the input voltage if 0.60 V, the output voltage is -1.8 V. Calculate the **value** of the feedback resistor. 2

5. (a) Draw the circuit for an op-amp in the **differential mode** with the resistor values chosen so that it will amplify a small p.d. across the inputs by a factor of 100x (up to saturation). 2

(b) Assuming a 15-0-15 volt power supply, what is the **maximum** input voltage which could be amplified without the amplifier reaching saturation? 1

Total = 25

Higher Physics **Radiation and Matter - Homework 1**

1. A loudspeaker is connected to a signal generator which makes an electrical vibration of 256 Hz. The speed of sound in air is 340 ms^{-1}. What is the **frequency** of the sound wave produced by the speaker? 1

2. A loudspeaker moves back and forward once in a time of 2.5 ms. Calculate its **frequency**. 2

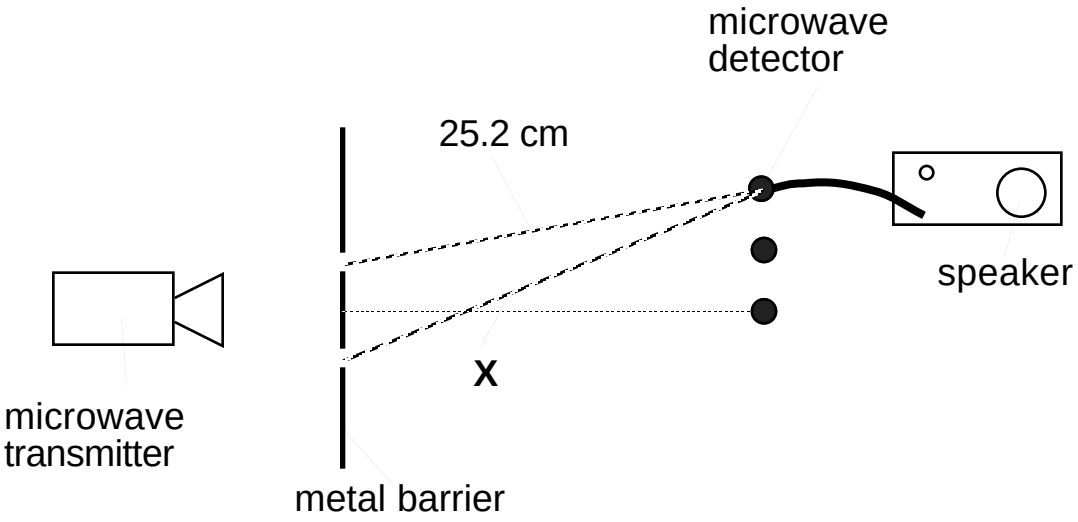
3. (a) Two waves are said to be "coherent". What does this mean? 1

   (b) Two water waves have the same amplitude. They meet at the same point in the water. A wave of double the amplitude of either is made where the waves meet.

   (i) What **kind** of interference has occurred?

   (ii) What can be said about the **phase relationship** between the waves. Draw a diagram to illustrate your answer. 3

4. Microwaves of wavelength 2.8 cm pass through two small slits in a metal barrier. The waves diffract through the slits, resulting in the probe detecting areas of constructive and destructive interference (indicated by loud and quiet sounds respectively from the speaker.)



The detector is shown in a position where it detects a point of constructive interference and it is the *second* one from the *central* loud position, as shown.

(a) Show that the distance '**X**' is 30.8 cm. 2

(b) The detector is now moved a little further from the centre and the speaker becomes silent. What is the new **path difference** between the detector and each slit?
Explain your answer. 2

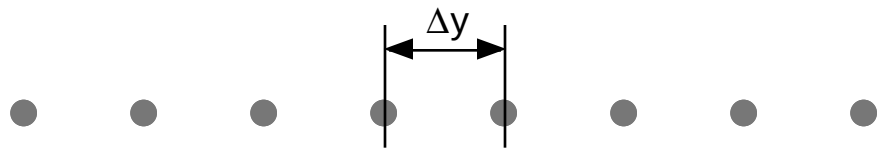
5. A laser beam is incident on a diffraction grating which has 5000 lines per cm. The wavelength of the laser light is 620 nm.

(a) Calculate the slit separation for the grating, in **metres**. 2

(b) State the value of light's wavelength in **metres**. 1

(c) Calculate the **angle** (with reference to the incident beam direction) at which the **3rd** constructive interference fringe would be observed. 2

(d) Interference fringes appear on a white screen a few metres from the grating as shown below.



What difference, if any, to the fringe separation, Δy, would be seen if

(i) light of a **longer** wavelength was used,

(ii) the grating used has **more** lines per centimetre? 2

6. (a) What is the approximate wavelength, in **nanometres**, of

(i) red light

(ii) blue light? 2

(b) Which colour, red or blue, is

(i) **refracted least** by a glass prism,

(ii) **diffracted most** by a grating? 2

7. (a) Describe what is meant by the 'normal' in ray diagrams. 1

(b) A ray of monochromatic light is incident on a glass block at an angle of 30^o to the normal. The angle of refraction in the glass is 19^o. Calculate the **refractive index** of the glass. 2

Total = 25

Higher Physics **Radiation and Matter - Homework 2**

1. (a) State the value of the **refractive index** of air. 1

   (b) A ray of monochromatic light, in a glass block, is incident on its boundary with the air at the critical angle.

   (i) What is the **size** of the refracted angle in the air?

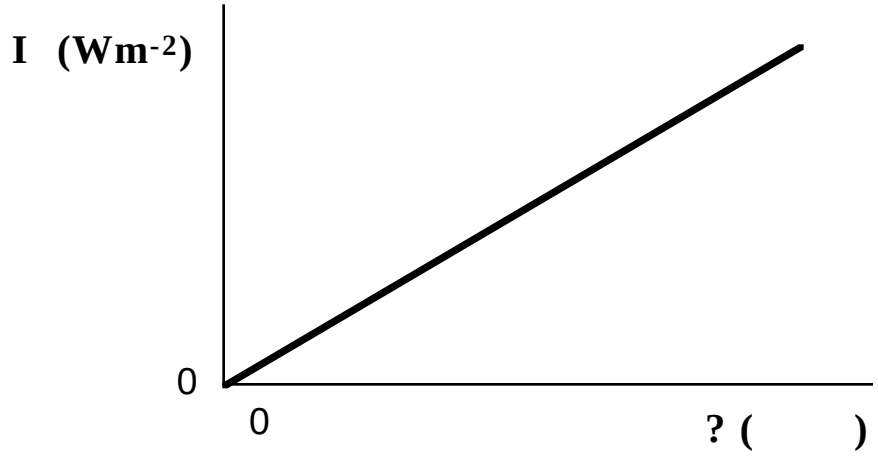
   (ii) What is the value of the critical angle if the refractive index of the glass is 1.62? (answer to 2 sig. figs.) 3

2. (a) The intensity of light from a point source is measured as 20 Wm^{-2} at a distance of 1.0 metre from the source.

   What would the **intensity** be at distances from the source of

   (i) 2.0 m (ii) 3.0 m (iii) 50 cm? 5

   (b) Copy this sketch graph showing the relationship between intensity (I) and distance (d) from a point source and complete the labelling of the x-axis by writing in the missing **quantity** and **unit**.



2

3. (a) What is name used for the *minimum* frequency at which radiation incident on a metal can produce a photoelectron? 1

   (b) Light of wavelength 5.1 x 10^{-7} m shines on a piece of clean sodium.

   (i) Calculate the **frequency** of the light.

   (ii) Calculate the **energy** carried by a photon of the light.

   (iii) The **work function** of sodium is 2.9 x 10^{-19} J.
   Calculate the *maximum* kinetic energy of a photoelectron. 5

4. Photons from a laser are incident on the surface of a photodiode of area $1.2 \times 10^{-5}\ m^2$ at the rate of 1.63×10^{18} every second.

If the light wavelength is 650 nm, calculate the resulting **intensity** on the diode's surface. 5

5. (a) "In a free atom, electrons occupy discrete energy levels".

In the above context, give the meaning of the terms

(i) *free* (ii) *discrete* 2

(b) The ionisation energy for a free hydrogen atom is 2.18×10^{-18} J. What is meant by this statement? 1

Total = 25