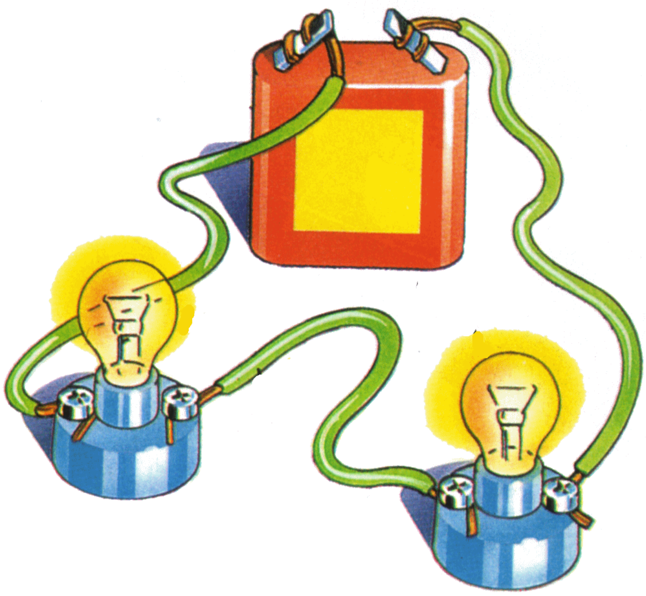
National 5

Energy and Electricity

Self Checks



DATA SHEET

Speed of light in materials

Material	*Speed* in $m\,s^{-1}$
Air	3·0 × 10^8
Carbon dioxide	3·0 × 10^8
Diamond	1·2 × 10^8
Glass	2·0 × 10^8
Glycerol	2·1 × 10^8
Water	2·3 × 10^8

Gravitational field strengths

	Gravitational field strength on the surface in $N\,kg^{-1}$
Earth	9·8
Jupiter	23
Mars	3·7
Mercury	3·7
Moon	1·6
Neptune	11
Saturn	9·0
Sun	270
Uranus	8·7
Venus	8·9

Specific latent heat of fusion of materials

Material	*Specific latent heat of fusion* in $J\,kg^{-1}$
Alcohol	0·99 × 10^5
Aluminium	3·95 × 10^5
Carbon Dioxide	1·80 × 10^5
Copper	2·05 × 10^5
Iron	2·67 × 10^5
Lead	0·25 × 10^5
Water	3·34 × 10^5

Specific latent heat of vaporisation of materials

Material	*Specific latent heat of vaporisation* in $J\,kg^{-1}$
Alcohol	11·2 × 10^5
Carbon Dioxide	3·77 × 10^5
Glycerol	8·30 × 10^5
Turpentine	2·90 × 10^5
Water	22·6 × 10^5

Speed of sound in materials

Material	*Speed* in $m\,s^{-1}$
Aluminium	5200
Air	340
Bone	4100
Carbon dioxide	270
Glycerol	1900
Muscle	1600
Steel	5200
Tissue	1500
Water	1500

Specific heat capacity of materials

Material	*Specific heat capacity* in $J\,kg^{-1}\,°C^{-1}$
Alcohol	2350
Aluminium	902
Copper	386
Glass	500
Ice	2100
Iron	480
Lead	128
Oil	2130
Water	4180

Melting and boiling points of materials

Material	*Melting point* in °C	*Boiling point* in °C
Alcohol	−98	65
Aluminium	660	2470
Copper	1077	2567
Glycerol	18	290
Lead	328	1737
Iron	1537	2737

Radiation weighting factors

Type of radiation	*Radiation weighting factor*
alpha	20
beta	1
fast neutrons	10
gamma	1
slow neutrons	3

National 5
ELECTRICITY AND ENERGY
Self Checks

Energy Changers

1. List the different types of energy.

2. What is meant by the Law of Conservation of Energy?

3. State the unit of energy and its abbreviation.

4. List the energy changes in the following examples:
   (a) An electric oven used to cook food
   (b) A light bulb
   (c) A falling stone
   (d) A loudspeaker in a stereo
   (e) Burning wood

Work

1. A gardener pushes a wheelbarrow with a force of 250 N over a distance of 20 m. Calculate how much work he does.

2. Joseph pulls his sledge to the top of a hill. He does 1 500 joules of work and pulls the sledge a distance of 50 metres. With what force does he pull the sledge?

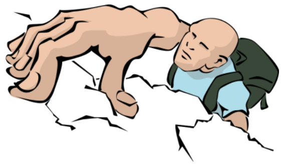
3. A car tows a caravan with a constant force of 2·5 kN over part of its journey. If the car does $8{\cdot}5 \times 10^6$ J of work calculate how far it pulls the caravan.

4. A tugboat tows a yacht out of a harbour. If the tugboat exerted a force of 110 kN and did 200 MJ of work calculate how far it towed the yacht.

5. On an expedition to the North Pole, Husky dogs were used to pull the sledges carrying supplies for the journey. One team of dogs did 650 MJ of work during the 1500 km journey.
   (a) Calculate the average force that the team of dogs exerted on the sledge.
   (b) There are 8 dogs in a team. Calculate the average force exerted by each dog during the journey.

6. A crane lifts a concrete block through a height of 40 m. The crane does 650 kJ of work. Calculate:
   (a) the weight of the concrete block
   (b) the mass of the concrete block.

7. Peter and John work at a supermarket. They are responsible for collecting trolleys from the trolley parks in the car park and returning them to the store.
   (a) Peter collects trolleys from the furthest trolley park. He has to pull them 150 m back to the store and collects 10 trolleys at a time. If Peter pulls the 10 trolleys together with an average force of 350 N calculate how much work he does in one journey.
   (b) John does not have so far to walk so he collects 20 trolleys at a time. He pulls his trolleys with an average force of 525 N and covers 100 m each journey. Calculate how much work he does in one trip.
   (c) Each boy has to return 80 trolleys to the store before finishing their shift.
      (i) Calculate how many journeys each boy has to make.
      (ii) Show by calculation who does the most work.



8. Marco climbs Ben Nevis. He weighs 600 N and climbs 8 m up the rock face. Calculate how much work he does.

9. A car moves 500m at constant speed. If the engine force is 1500N, what is the work done by the car?

10. In a supermarket shop assistants are asked to stack the shelves with tins of beans. Each tin of beans has a mass of 450 g. Jane lifts 150 cans of beans from the box on the floor to the middle shelf. The shelf is 140 cm from the floor.
    (a) Calculate the weight of 150 cans of beans.
    (b) Calculate how much work Jane does.
    (c) Martin has been asked to stack the top shelf. The top shelf is 200 cm from the floor. He lifts 150 cans of beans from the box on the floor onto the shelf. Calculate how much more work he does than Jane.

Potential Energy

1. How does an object gain potential energy?

2. State the equation for calculating potential energy, state the units of each quantity.

3. Find the missing values in the following table:

	Mass (kg)	Gravitational Field Strength (N/kg)	Height (m)	Potential Energy (J)
(a)	25	9.8	15	
(b)	30	9.8	45	
(c)	35	9.8		450
(d)	2	9.8		70
(e)		9.8	5	120
(f)		9.8	57	6000

4. A pot holer of weight 70 kg climbs 60 m. How much potential energy does he gain?

5. A car containing 4 passengers has a total mass of 1200 kg. How much potential energy does it lose if it accelerates down a 40 m high slope?

6. Calculate the potential energy gained by a ping pong ball lifted to a height of 2m if it has a mass of 30 g.

7. Calculate the mass of a skier if he loses 78 000 J of potential energy when skiing down a slope of 120 m.

8. Water in the reservoir of a hydroelectric power station 'holds' 120 MJ of potential energy. The mass of water is 120 tonnes (1 tonne = 1000 kg). Calculate the height of the stored water.

9. A mountain rescuer is trying to rescue a group of climbers stranded on a ledge 250 m above ground level. The only way to reach the climbers is to climb down to them from another ledge 440 m above ground level. If the mountain rescuer has a mass of 85 kg calculate:
   (a) the potential energy gained initially by climbing to the higher ledge
   (b) the amount of potential energy he **loses** as he climbs to the lower ledge.

10. A girl gains 200J of potential energy by cycling up a slope. When she reaches the bottom she has 180J of kinetic energy.
   (a) how much energy has been "wasted"?
   (b) What form would this "wasted energy" take?

Kinetic Energy

1. Find the missing values in the following table.

	Mass (kg)	**Velocity (m/s)**	**Kinetic energy (J)**
(a)	2·0	3·0	
(b)	0·5	15·0	
(c)	4·5		36.0
(d)	4·0		50.0
(e)		10·0	12.0
(f)		200·0	400000.0

2. Calculate the kinetic energy of a car travelling at 15 m/s if the car has a mass of 1 200 kg.

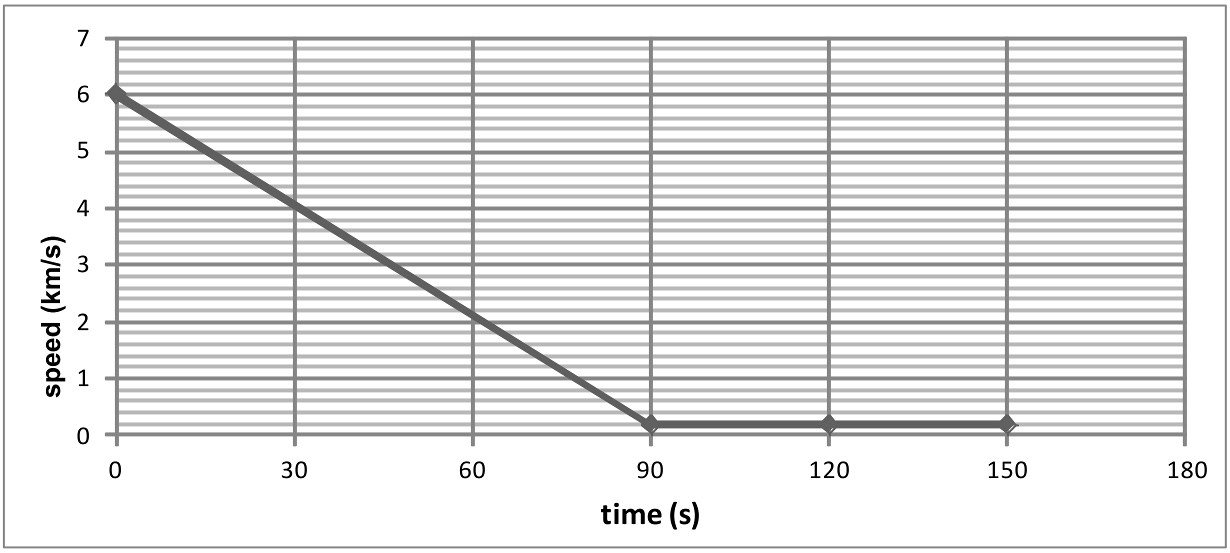
3. A mass of 2 kg falls from a table and has a speed of 4·4 m/s just before it hits the ground. How much kinetic energy does it have at this point?

4. A long distance runner has a mass of 70 kg. If he crosses the finishing line with a speed of 5·4 m/s, how much kinetic energy does he have at the finishing line?

5. A 50 000 kg train is travelling at 72 km/h.
   (a) What is its speed in m/s?
   (b) How much kinetic energy does the train have?

6. The graph below shows how the speed of a space capsule decreased as the capsule re-entered the Earth's atmosphere.

   If the space capsule had a mass of 4 500 kg, how much kinetic energy did it lose as it re-entered the Earth's atmosphere?

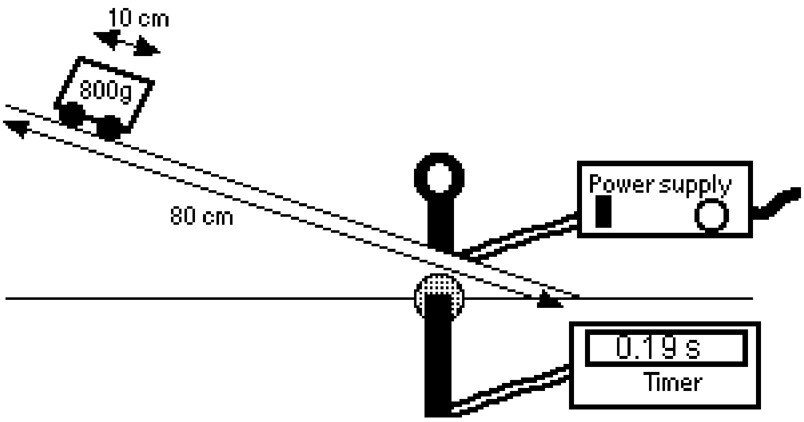


7. What is the speed of a ball which has 114 J of kinetic energy and a mass of 2·28kg?

8. Find the mass of an apple given that the apple is rolling along a table at 0·8 m/s and has 0·04 J of kinetic energy.

9. A trolley rolls down a ramp which is 80 cm long. It passes through a light gate near the bottom of the ramp and the timer records a time of 0·19 s for the trolley to cut the light beam.

   The mass of the trolley is 800 g and it has a length of 10 cm.
   (a) What is the speed of the trolley as it passes through the light gate?
   (b) How much kinetic energy does it have as it passes through the light gate?



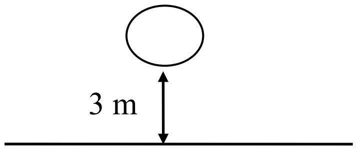
10. A minibus of mass 2800 kg was travelling with a speed of 10 m/s. It then accelerated at a rate of 0·8 m/s^2 for 10 seconds.
   (a) What was the kinetic energy of the minibus while it was travelling at 10 m/s?
   (b) What was the speed of the minibus after 10 seconds of acceleration?
   (c) How much kinetic energy did the minibus gain during the acceleration period?

11. A motor cycle and a 5000 kg bus have equal amounts of kinetic energy. The motor cycle is travelling at 35 m/s and has a mass, including rider, of 370 kg.
    (a) How much kinetic energy does the motorcycle have?
    (b) Calculate the speed of the bus.

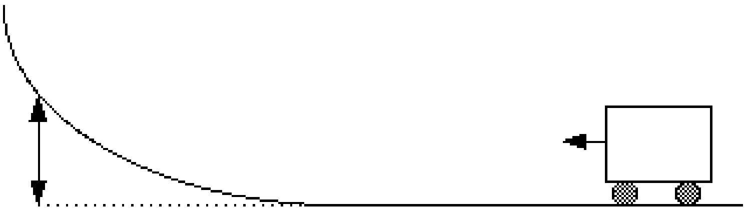
12. A tennis ball has a mass of 50 g. During a game a player lobs the ball over the net giving it a speed of 10 m/s as it leaves the racket. If the ball loses 0·475 J of kinetic energy during its flight what is its speed on reaching the other player?

Conservation of Energy

1. A 2 kg ball falls through 3 m to land on Earth.
    (a) How much potential energy does it lose during its fall?
    (b) How much kinetic energy does it gain during its fall, assuming that there is no air resistance?
    (c) Calculate the maximum speed of the ball as it hits the ground.

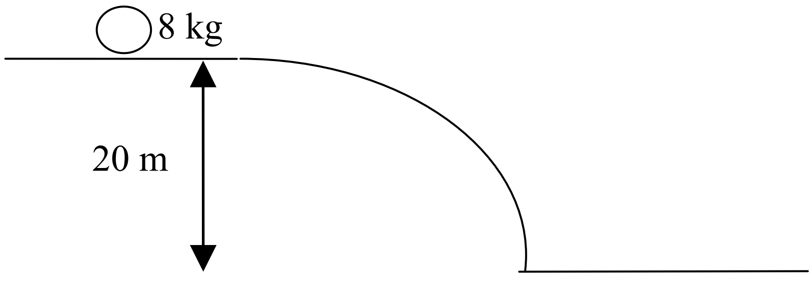


2. A trolley rolls towards a ramp with a speed of 2 m/s. The trolley has a mass of 0·3 kg.



    (a) Calculate the kinetic energy of the trolley before it goes up the ramp.
    (b) If there are no energy losses due to friction how much potential energy does the trolley gain as it goes up the ramp?
    (c) What height does the trolley reach on the ramp?

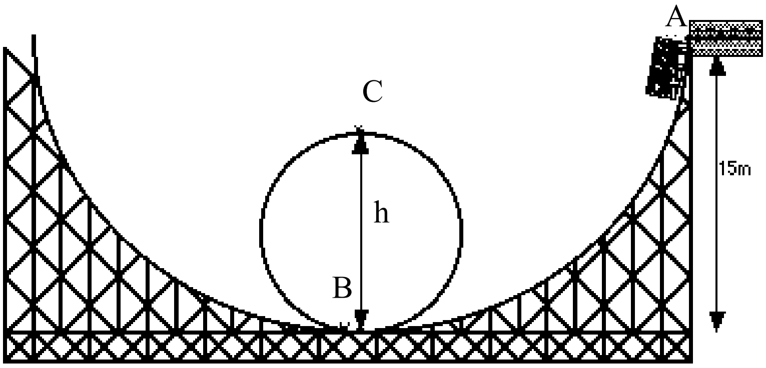
3. An 8 kg boulder rolls down a hill as shown below.
    (a) How much potential energy does the boulder lose as it rolls, assuming that no energy is lost due to friction?
    (b) Calculate the speed of the boulder at the bottom of the hill.



4. A box is released from a helicopter which is hovering 10 m above the ground. Calculate the speed of the box as it strikes the ground, assuming that frictional effects are negligible.

5. If a bullet is fired vertically upwards, with a speed of 150 m/s, what is the maximum height it could reach? (Assume that frictional effects are negligible.)

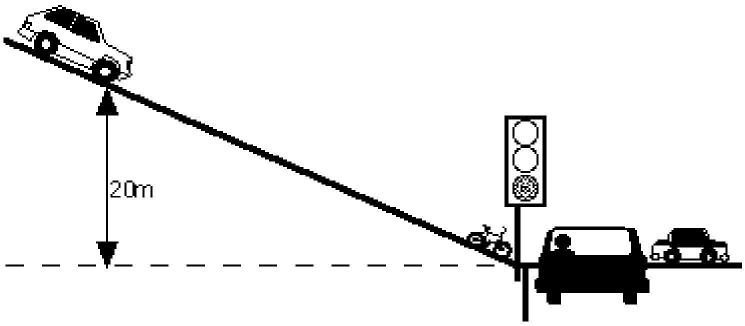
6. A typical loop-the-loop rollercoaster in a fun park is shown below :



During one ride the total mass of carriage and passengers was 3 000 kg. When all passengers were locked in place the carriage was pulled up the track to the start point A. This was at a height of 15 m. The carriage was then released and it sped down the track past point B and round the loop. By the time it had reached the top of the loop, point C, it had lost 6 000 J of energy due to friction and was travelling at 8 m/s.

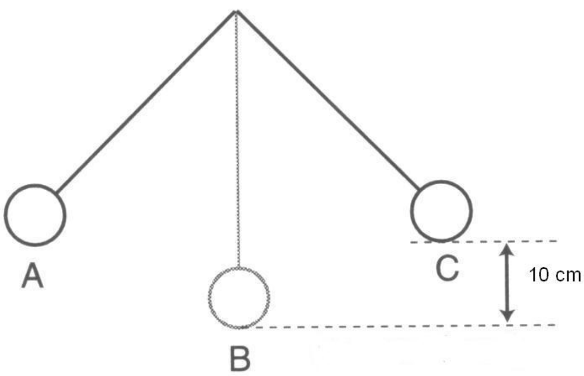
(a) How much potential energy did the carriage lose in going from A to B?
(b) How much kinetic energy did the carriage have at the top of the loop?
(c) How much potential energy did the carriage regain between B and C?
(d) Calculate the height of the loop.

7. A car, of mass 1 500 kg, is parked on a hill at a height of 20 m. The brakes fail and the car begins to roll towards a busy junction at the foot of the hill. The car reaches the junction with a speed of 18 m/s.



(a) Calculate the amount of potential energy lost by the car as it rolled down the hill.
(b) How much kinetic energy did the car have at the junction?
(c) How much energy was 'lost' due to friction as the car rolled down the hill?

8. A pendulum swings from A to C and back, as shown in the diagram. Points A and C are the extreme points of the swing. The mass of the bob is 0.4 kg.



(a) Calculate the maximum potential energy of the bob.
(b) What is the maximum kinetic energy of the bob?
(c) Find the maximum speed of the bob.

Power

1. Define power.

2. State the equation for calculating power, state the units of each quantity.

3. Find the missing values in the following table.

	Power (W)	Energy (J)	Time (s)
(a)		36 500	15
(b)		7 320	125
(c)	65		10
(d)	$1{\cdot}2 \times 10^4$		0·3
(e)	100	6×10^3	
(f)	$2{\cdot}5 \times 10^4$	540	

4. A firework rocket gains 135 joules of energy in 4 seconds. Calculate the power of the rocket motor.

5. If a toy motor boat gains 350 J in 30 seconds calculate the power of its electric motor.

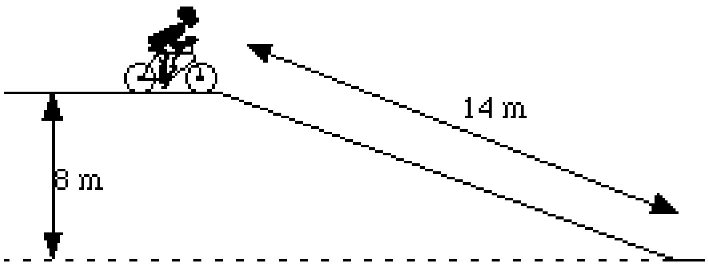
6. How much energy can a 20 W engine produce in 45 seconds?

7. A Ferrari is a more powerful car than a Fiat. The Ferrari has a power of 100 kW and the Fiat has a power of 45 kW. Calculate how much energy each car engine could transfer in 8 minutes.

8. At a horse show there are many different competitions such as show jumping and dressage. Often there are horse and carriage races. During such a race one horse pulled its carriage with an average force of 130 N over the 1 km race course.
   (a) Calculate the work done by the horse during the race.
   (b) The horse took 3 minutes to complete the course. Calculate the power of this animal.

9. A train is travelling at a constant speed of 30 ms^{-1} when the driver spots some obstruction on the track ahead. He immediately pulls the emergency brakes and the train comes to rest in 8 seconds. The mass of the train is 80 000 kg and the average braking force is 750 000 N.
   (a) How much kinetic energy did the train have before braking?
   (b) The obstruction, a fallen tree, was 125 m from the train at the instant the driver pulled the brakes. Did the train collide with the tree? Justify your answer.
   (c) Calculate the braking power of the train.

10. A cyclist on a cycle path stops at the top of a slope and decides to free wheel down the slope.
The slope is 8 m high and 14 m long, and the combined mass of cyclist plus bicycle is 80 kg. An average force of 300 N opposes the cyclist as he travels down the slope. This is due to friction and air resistance.



(a) How much gravitational potential energy does the cyclist lose as he travels down the slope?
(b) How much work does the cyclist do against friction and air resistance on the slope?
(c) How much kinetic energy does the cyclist have at the foot of the slope?
(d) Calculate the speed of the cyclist at the foot of the slope.
(e) If friction and air resistance amount to 320 N on the flat surface how far will the cyclist travel before these frictional forces bring him to rest?

Charge

1. The following set of items have to be divided into conductors and insulators. Paper clip, rubber, pencil refill ‘lead’, wooden ruler, scalpel, glass rod, tongs
   (a) Describe a simple experiment which you could carry out to determine whether the items are conductors or insulators.
   (b) i) What family of materials, in general, do all conductors fall into?
   ii) What item in the above list is the exception to this ‘rule’?

2. State the two types of electrical charge.

3. Describe the difference between electrons in an insulator and a conductor.

4. (a) Explain what is meant by the term ‘electric current’.
(b) Write down the relationship between charge and electric current.
(c) Which units are used to measure charge, current and time?

5. Find the missing values in the following table.

	Charge (C)	Current (A)	Time (s)
(a)		5	30
(b)		0·005	3 600
(c)	3	1·5	
(d)	27·6	2·3	
(e)	1 800		60
(f)	94		10

6. A bulb draws a current of 1 A. How much charge flows through it in 60 seconds?

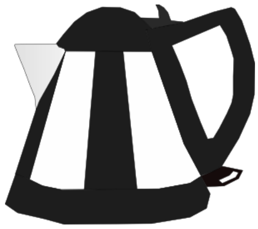
7. 756 C of charge flow though an electric heater in 180 seconds. What is the current in the heater?

8. A hairdryer operates with a current of 5 A. How much time would it take for 6 000 C to pass through the hairdryer.

9. A 60 W bulb is switched on for 30 minutes. If 450 C pass through it in this time, what is the current flowing in the bulb?

10. An electric kettle has a label on it as shown below.

MODEL No. 5510 - 01
capacity 1·7 litres
9·2 A /220 - 240 V
2·2 kW



After the kettle is switched on it automatically switches off when the water has boiled. On one occasion 1 656 C passed through the kettle before it switched off. Use the information given to work out how long the water took to boil?

11. An electric fire is rated at 2·875 kW, 230 V, 12·5 A. How much charge will flow through this fire in a period of 2 hours 20 minutes?

12. One bar of an electric heater draws a current of 4 A from the mains supply.
    (a) How much charge flows through the bar each minute?
    (b) If a second bar is switched on, the charge flowing through the bar each minute increases to 440 C. Calculate the new current drawn from the mains when both bars are switched on.

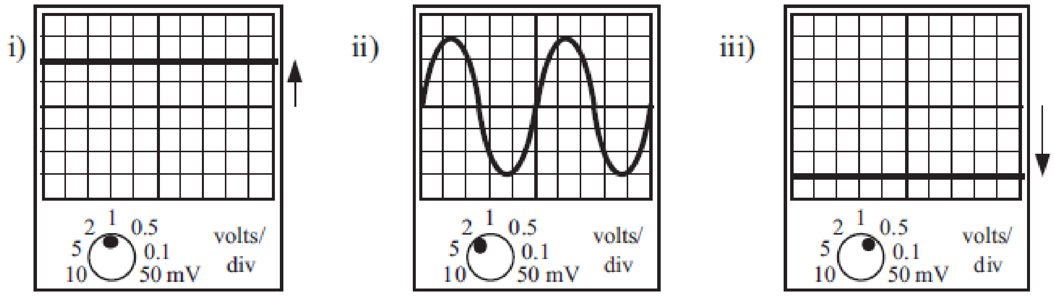
13. The manufacturer of a car battery states that the battery is rated at 40 ampere hours. This tells the user how long the battery will be able to provide electric current.
eg. this could deliver 40 A for 1 hour or 8 A for 5 hours etc.
    (a) Calculate the total charge that this battery can deliver, in coulombs.
    (b) The parking lights of the car draw a current of 2 A from the battery. If these lights were left on when the car was parked, calculate the minimum time it would take for the battery to go flat.
    (c) State any assumption you are making in your answer to part (b).

AC/DC

1. Explain the difference between a.c. and d.c. Your answer should state what is represented by the terms a.c. and d.c. and include the words 'electron' and 'direction'.

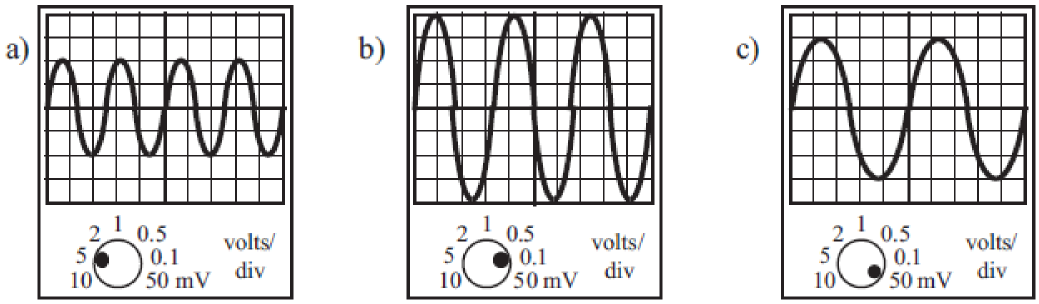
2. Give two examples each of
    (a) a.c. power supplies
    (b) d.c. power supplies.

3. (a) For each of the following traces shown, state whether they are a.c. or d.c.



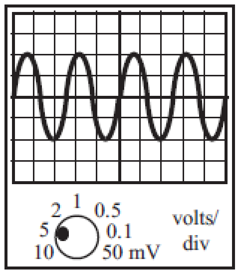
(b) Calculate
i) the applied voltage for trace i) where the Y-gain setting is set at 1 V/division
ii) the peak voltage for trace ii) where the Y-gain setting is set at 2 V/division.
iii) the applied voltage for trace iii) where the Y-gain setting is set at 0.5 V/ division

4. Calculate the peak voltages of the traces below using the Y-gain settings shown.

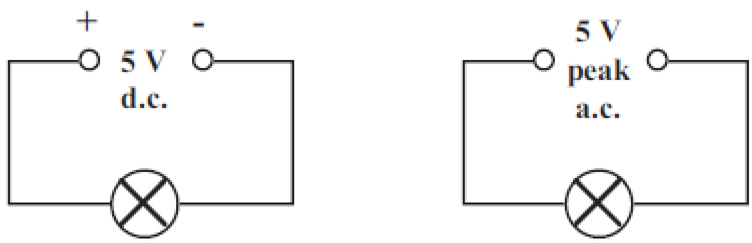


5. (a) State whether the mains supply is a.c. or d.c.
(b) What is the frequency of the mains supply?

6. The trace to the right is produced from the mains supply. If the settings on the oscilloscope are not changed, sketch the trace that would be produced by the following a.c. supplies.
(a) Peak voltage 5 V at a frequency of 25 Hz
(b) Peak voltage 20 V at a frequency of 75 Hz.



7. Two identical bulbs are lit by the supplies shown below.



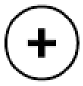
(a) Which bulb will be the brighter? Explain your answer.
(b) The d.c supply is altered so that both bulbs have the same brightness. The a.c. supply remains at the 5 V peak value. Was the d.c. supply increased or decreased?

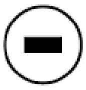
8. An a.c. supply measured with a voltmeter is 12 V. The peak voltage is measured using an oscilloscope.
   (a) Which of the values below is likely to be the measured peak voltage: 17 V, 12 V, 8.5 V, 6 V?
   (b) Explain your answer.

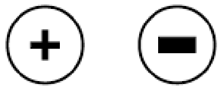
9. Briefly explain the meaning of the term ‘effective voltage’ which is applied to an a.c. supply.

Electric Fields

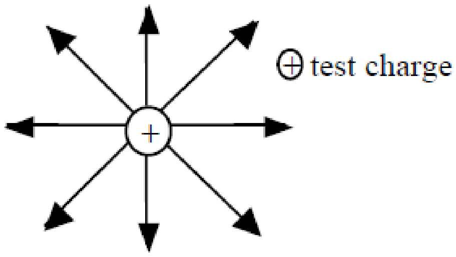
1. Draw the electric field pattern for the following charges:

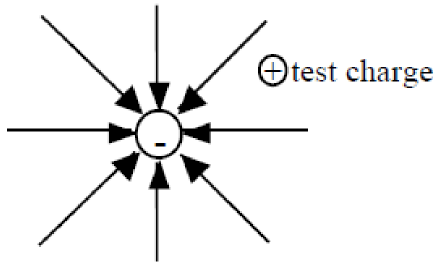
(a) 

(b) 

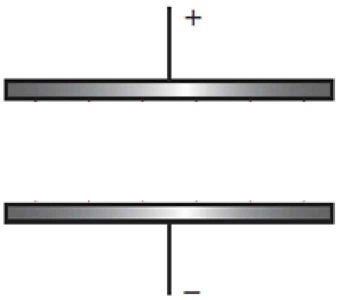
(c) 

2. Describe the motion of the small test charges in each of the following fields.

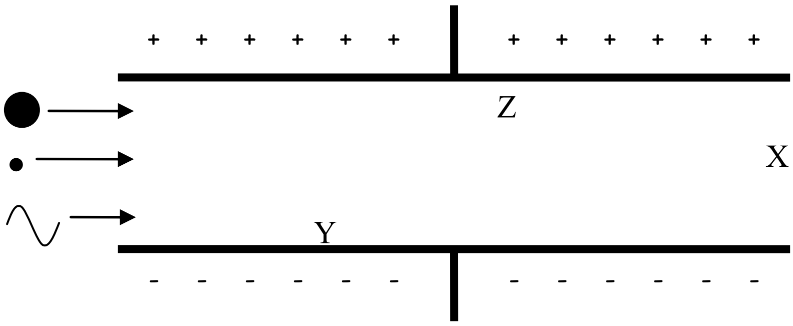
(a) 

(b) 

3. Draw the field lines for the following two parallel plates.



4. An alpha particle, a beta particle and a gamma ray enter an electric field at right angles to the field. Which letter shows the most likely position of the:
   (a) Alpha particle (b) Beta particle (c) Gamma ray



5. Describe what happens to electric charges in a conductor when an electric field is applied across the conductor.

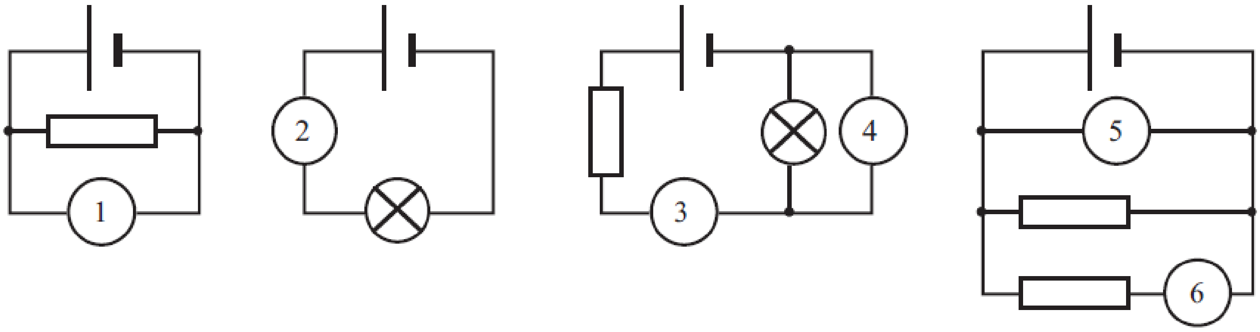
6. Define voltage in terms of energy and charge.

Circuit Components

1. Copy and complete the table below.

Component	Symbol	Function
Cell		
Battery		
Lamp		
Switch		
Resistor		
Variable resistor		
LDR		
Thermistor		
Voltmeter		
Ammeter		
Diode		
LED		
Fuse		
Relay		

3. In the circuits below, identify the meters 1 to 6.

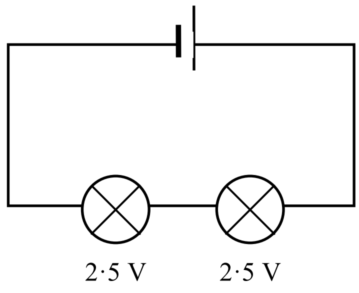


Series Circuits

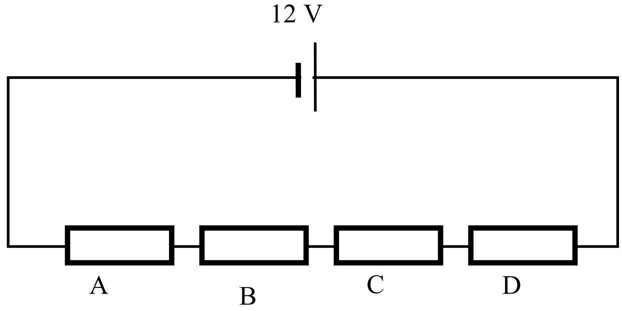
1. (a) Write down the rule for the current at all points in a series circuit.
   (b) Write down the relationship between the supply voltage and the potential differences (voltages) across the individual components in a series circuit.

2. Which of the following statements is/are true for **series** circuits.
   A There is only one pathway round the circuit.
   B There is more than one pathway around the circuit.
   C The potential differences around the circuit add up to the supply voltage.
   D The potential difference (voltage) is the same across all components.
   E The current is the same at all points in the circuit.
   F The current through each component adds up to the supply current.

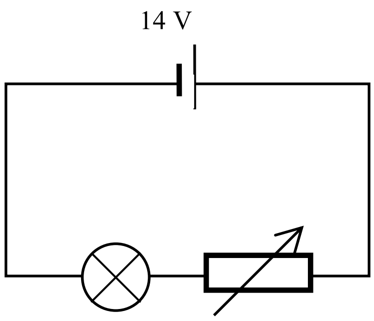
3. Two identical 2·5 V bulbs are connected to a supply as shown. What is the voltage of the supply?



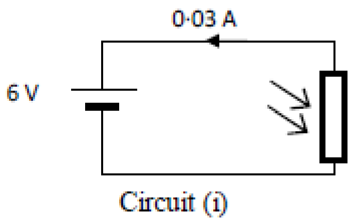
4. Four identical resistors are connected across a 12 V supply as shown in the diagram. What is the voltage across each of the resistors?

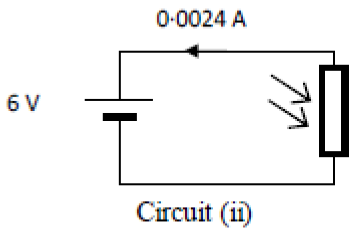


5. A variable resistor is used as a dimmer switch in a simple series circuit as shown. The variable resistor is adjusted until the bulb is shining brightly. The voltage across the bulb is 13·8 V and the current through the variable resister at this setting is 1·7A.
   (a) Calculate the voltage across the variable resistor.
   (b) What is the current flowing in the bulb?



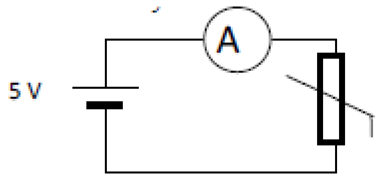
6. The circuits below show two identical LDR's each connected to a 6 V supply. One LDR is placed in a cupboard and the other is placed beside a window.





   (a) Calculate the resistance of each LDR.
   (b) State which circuit shows the LDR in the cupboard.

7. The following circuit shows a thermistor connected to a 5 V supply and placed in a school laboratory. One morning the ammeter gave a reading of 1·25 mA. Later in the same day the reading had risen to 2·5 mA.



(a) Calculate the resistance of the thermistor in the morning.
(b) State what happened to the temperature in the room during the day? Explain your answer.

8. The following information for an LDR was found in a components catalogue. This LDR is connected to a 12 V supply with an ammeter in series.

Light Source	Illumination (lux)	Resistance (kΩ)
moonlight	0·1	10 000
60 W bulb at 1m	50	2·4
fluorescent light	500	0·2
bright sunlight	30 000	0·02

(a) Determine the resistance, in ohms, of the LDR when exposed to fluorescent light?
(b) Calculate the ammeter reading when a lamp with a 60 W bulb is placed 1 m away from the LDR?
(c) For one source, he ammeter gives a reading of 0·6 A. Determine which light source is being used.

9. A pupil uses a thermistor as a simple electronic thermometer. She connects the thermistor to a 6 V supply and an ammeter and places the thermistor into a beaker of hot water. The ammeter gives a reading of 8 mA.

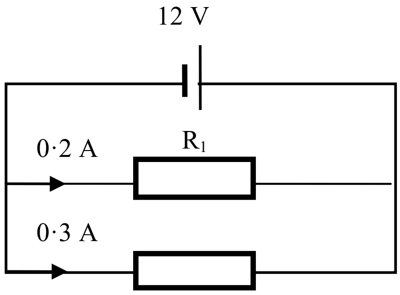
Temperature (°C)	*Resistance* (Ω)
20	3 750
40	198
60	750
80	350
100	200

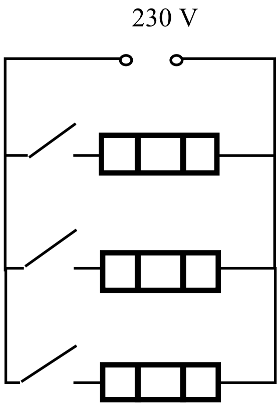
(a) Determine the temperature of the water in the beaker?
(b) The pupil adds some more water to the beaker and the ammeter gives a new reading of 1·6 mA. Determine whether the pupil added hot or cold water to the beaker.
(c) Calculate the new temperature of the water.
(d) Determine the ammeter reading when the water reaches boiling point.

Parallel Circuits

1. (a) Write down the relationship between the supply current and the currents in the branches of a parallel circuit.
   (b) Write down the potential difference (voltage) rule for all components that are connected in parallel.

2. Two resistors are connected in parallel to a 12 V battery.
   (a) What is the voltage across R1?
   (b) What is the voltage across R2
   (c) What size of current is drawn from the battery?

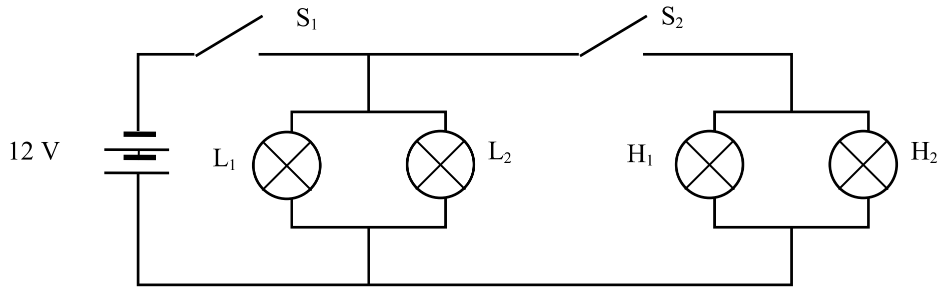




3. An electric fire has three elements which can be switched on and off independently. The elements are connected in parallel to the mains supply. Each element draws a current of 0·3 A when switched on.
   (a) What is the voltage across the middle element?
   (b) What is the total current flowing from the supply when two of the elements are switched on?
   (c) What is the maximum current drawn from the mains by the fire?

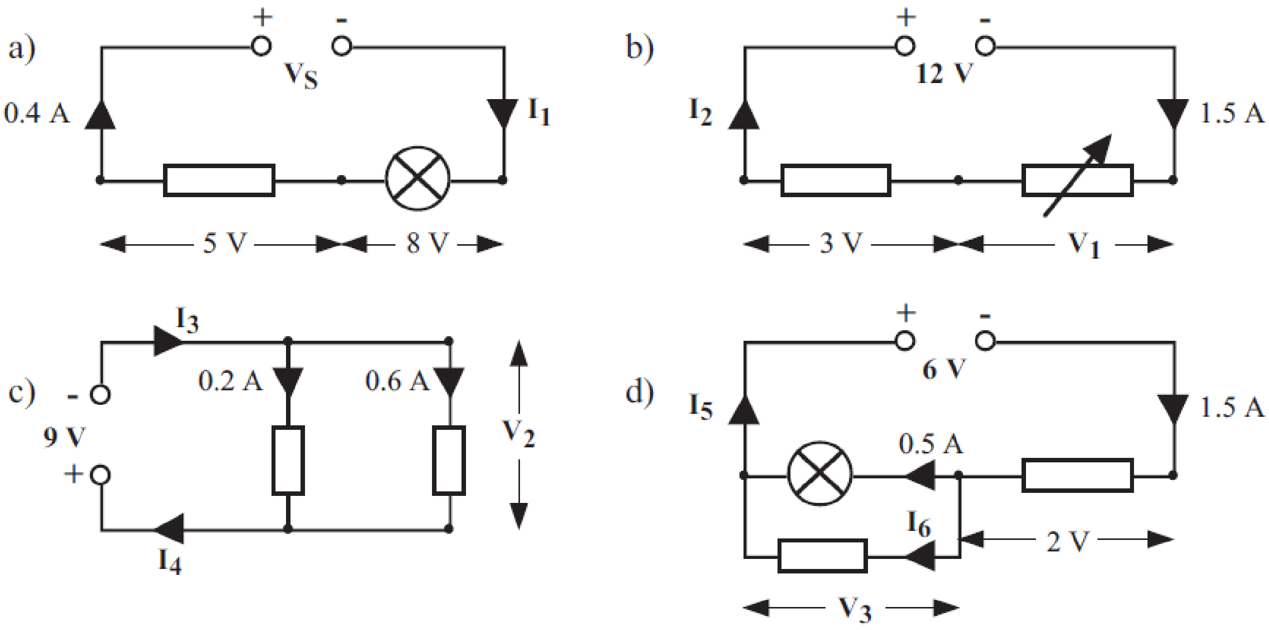
4. Which of the following statements is/are true for **parallel** circuits.
   A There is only one pathway round the circuit.
   B There is more than one pathway around the circuit.
   C The potential differences around the circuit add up to the supply voltage.
   D The potential difference (voltage) is the same across all components.
   E The current is the same at all points in the circuit.
   F The current through each component adds up to the supply current.

5. The headlamps and side lights in a car are connected in parallel. The diagram below shows how they are connected. The side lights (L_1 & L_2) may be switched on by themselves using switch S_1. The headlights (H_1 & H_2) are switched on by switch S_2 and only come on if the sidelights are already on.



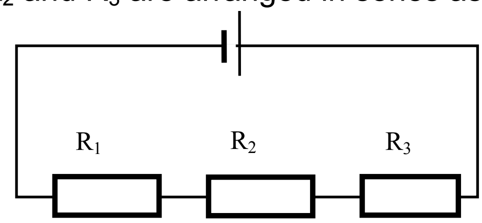
   (a) What is the voltage across the sidelight L_1?
   (b) What is the voltage across the headlight H_2?
   (c) Each sidelight draws a current of 3 A from the car battery. What is the total current drawn from the battery when S_1 only is closed?
   (d) Each headlight draws a current of 5 A from the car battery. What is the total current drawn from the battery when S_1 and S_2 are closed?

6. Find the missing currents and voltages in the following circuits.



Resistors in a Series Circuit

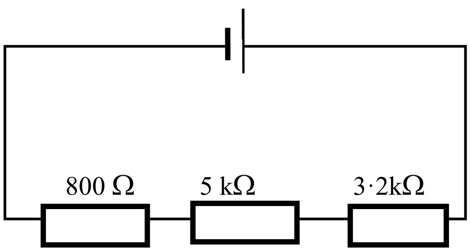
1. Three resistors R_1, R_2 and R_3 are arranged in series as shown in the diagram to the right.

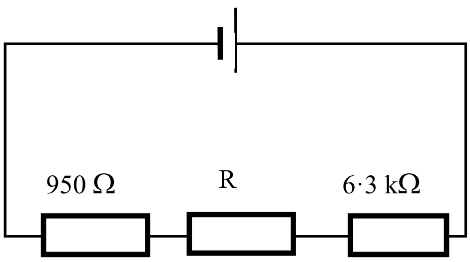


2. Find the missing values in the table.

	R_1 (Ω)	R_2 (Ω)	R_3 (Ω)	R_s (Ω)
(*a*)	5 000	490	85	
(*b*)	80	300	25	
(*c*)	800	2 000	200	
(*d*)	700	300		1 400
(*e*)		140	100	550

3. Calculate the total resistance of the following circuit.



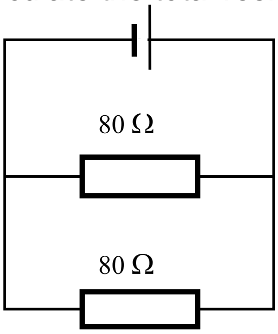


4. The resistance of the following circuit is 8·8 kΩ. Calculate the resistance of R.

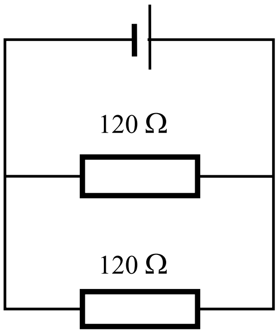
Resistors in a Parallel Circuit

1. Calculate the total resistance of each of the following circuits:

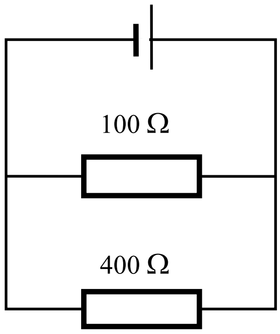
(a)



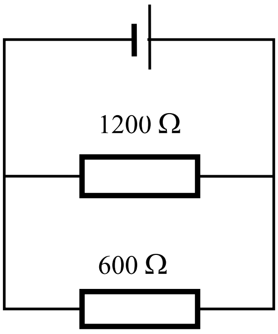
(b)



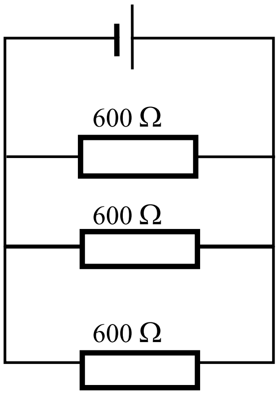
(c)



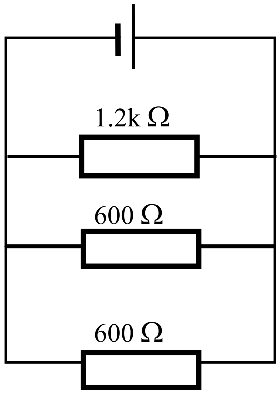
(d)



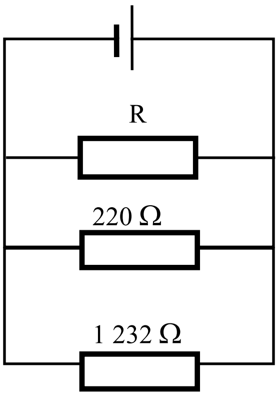
(e)



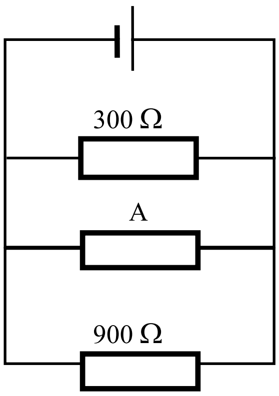
(f)



2. The total resistance of the circuit below is 80 Ω. Calculate the resistance of R.



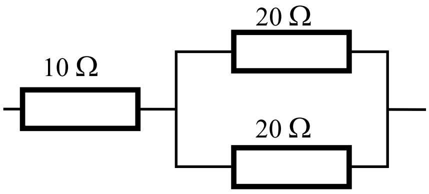
3. The total resistance of the following circuit is 112·5 Ω. Calculate the resistance of resistor A.



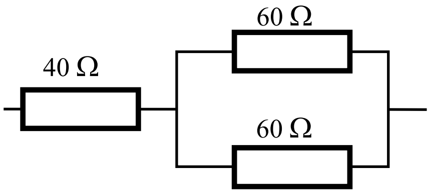
Combination Circuits

1. Calculate the total resistance in each of the following networks:

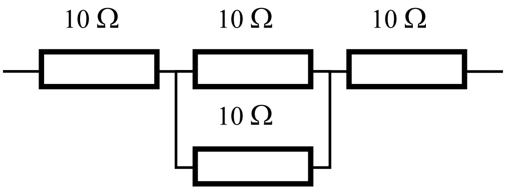
(a)



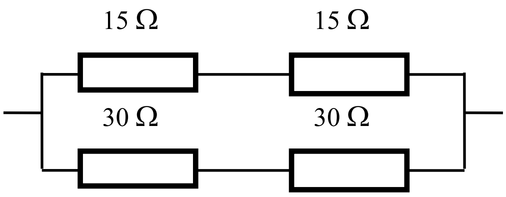
(b)



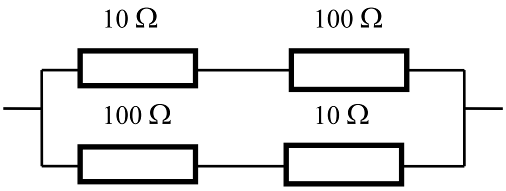
(c)



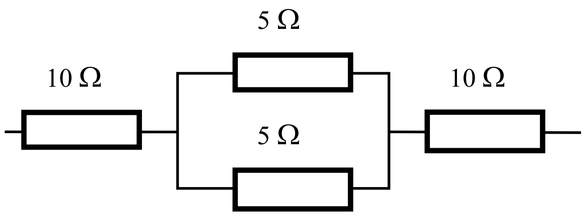
(d)



(e)

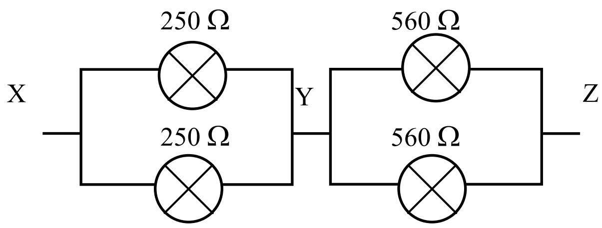


(f)

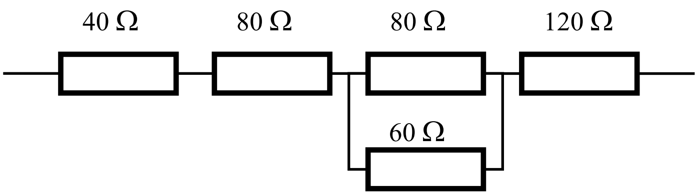


2. The following circuit shows part of a car lighting system.

Calculate the resistance between points:
   (a) X and Y
   (b) Y and Z
   (c) X and Z.



3. Calculate the resistance of the network of resistors shown below.



4. Draw a diagram of a ring circuit (house power circuit).

5. Describe the benefits of a ring circuit (house power circuit) over a standard parallel circuit.

Ohms law

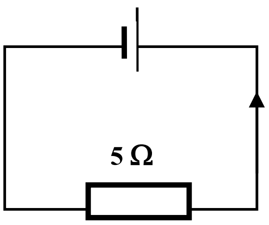
1. Rewrite the following list of currents in amperes and then arrange in order of increasing value.
   5805 mA, 2 mA, 29 mA, 120 A, 8.9 A, 0.03 A

2. In a series circuit, the ammeter reading was noted for different values of resistor in the circuit.
   (a) Which electrical quantity does the ammeter measure?
   (b) Copy and complete the table below, placing the ammeter readings in the correct order.
   0.6 A, 2.4 mA, 1.2 A, 240 mA.

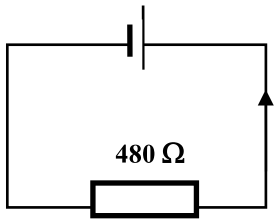
Resistor (Ω)	Current
5	
10	
20	
2.5 k	

3. Look at the following circuits and calculate the supply voltage in each case:

(a)

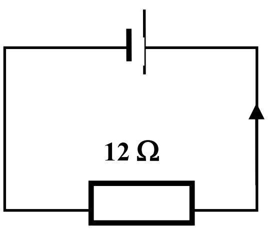


(b)

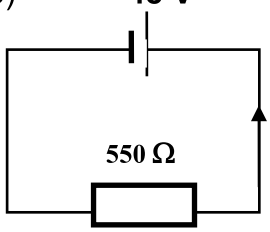


4. Look at the following circuits and calculate the current in each case:

(a)

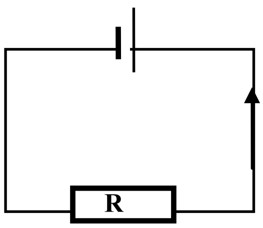


(b)

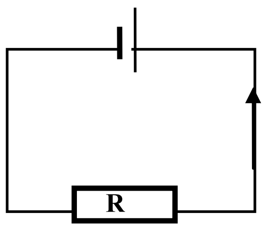


5. Look at the following circuits and calculate the unknown resistance in each case:

(a)



(b)



6. Calculate the resistance of a lamp if the current through it is 10 mA when operated by a 24 V supply.

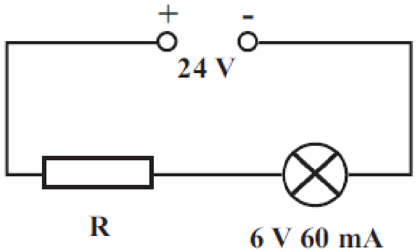
7. A power drill is operated at mains voltage and has a resistance of 1·5 kΩ. Calculate the current through the drill.

8. The maximum current an electric motor can safely handle is 10 mA and it has a resistance of 360 Ω. Calculate its safe operating voltage.

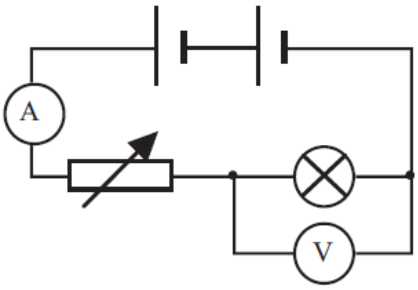
9. Hairdryers work from the mains voltage and can have currents of up to 15 mA flowing through them. Calculate the resistance of the hairdryer.

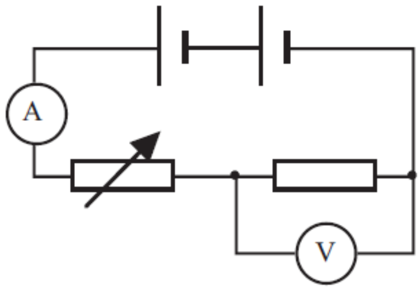
10. Overhead cables have resistance of 25 kΩ. If the voltage across the cables is 4000 V calculate the current through them.

11. The diagram below shows a 6 V 60 mA lamp working off a 24 V supply.
    (a) What must be the potential difference across the resistor if the lamp is operating correctly?
    (b) Calculate the value of resistor R.



12. Potential difference and current were measured in both circuits below for different values of current





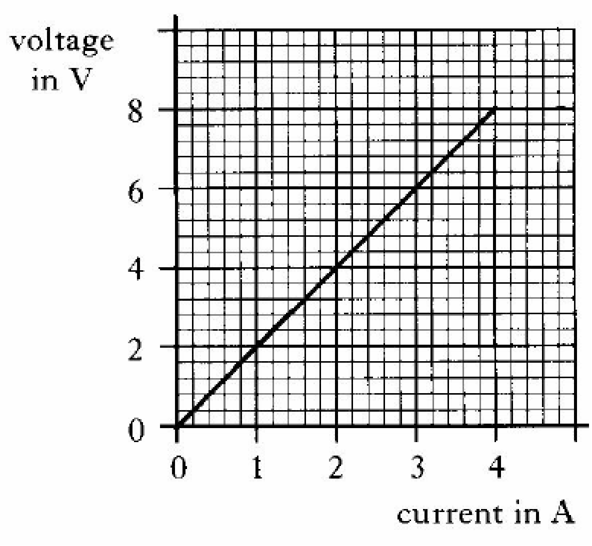
V (V)	I (A)	V/I (ohms)
2.4	0.24	
3.1	0.30	
3.6	0.34	
4.8	0.40	

V (V)	I (A)	V/I (ohms)
2.4	0.24	
3.0	0.30	
3.4	0.34	
4.0	0.40	

(a) Copy and complete both tables.
(b) What is the purpose of the variable resistor in the above circuits?
(c) What conclusion can be drawn about the resistance of the lamp bulb as the current increases?
(d) What conclusion can be drawn about the resistance of the resistor as the current increases?
(e) **Explain** the difference in the behaviour of the lamp bulb and the resistor as the current increases.

Ohms Law Graphical Analysis

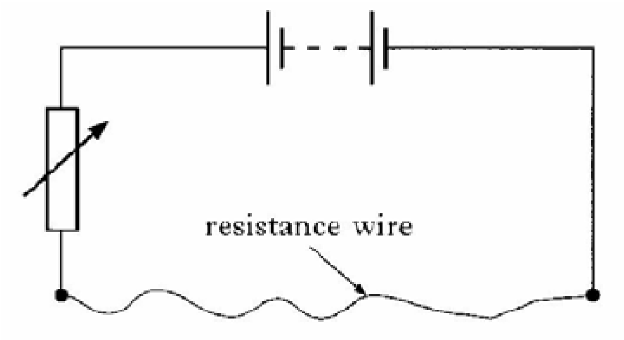
1. The graph shows the relationship between the voltage across a resistor and the current in the resistor



(a) What is the relationship between voltage and current?

(b) What is the resistance of the resistor?

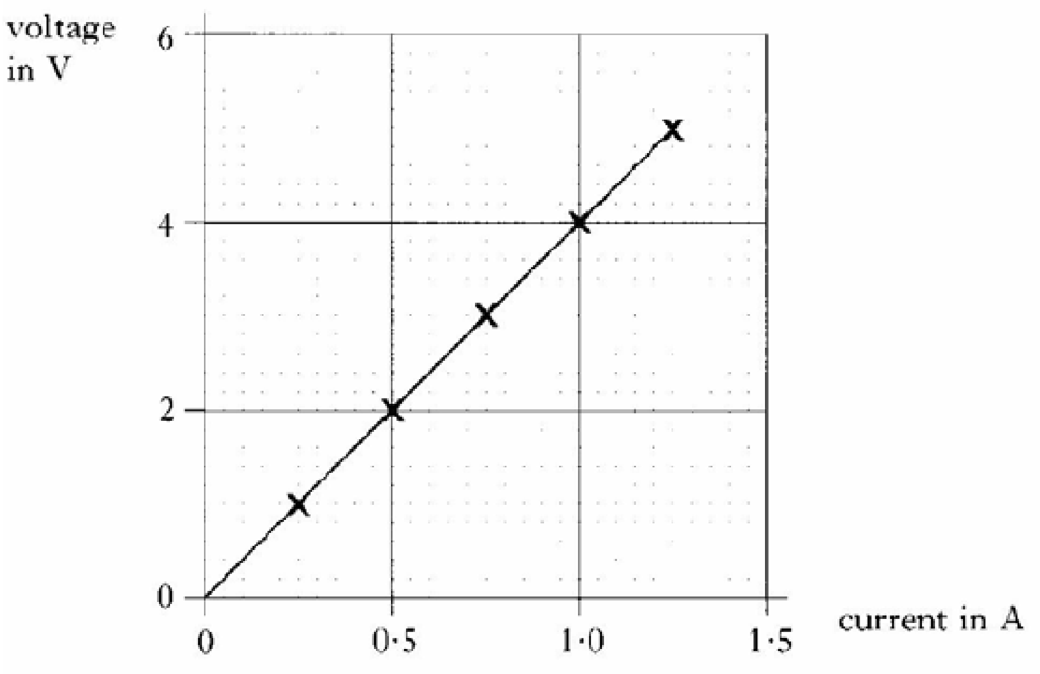
2. A student is given a piece of resistance wire 200 mm long and is asked to find its resistance. Part of the circuit the student builds is shown below.



The student is also provided with a voltmeter and an ammeter.

(a) Redraw the diagram to show how the student should connect the meters to measure the resistance of the wire.

(b) The student now uses the measurements from the experiment to draw the following graph.

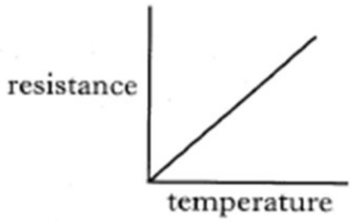


(i) Describe how the student uses the circuit to obtain the measurements for the graph

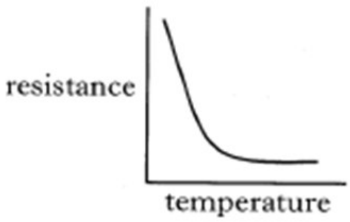
(ii) Calculate the resistance of **one metre** of the wire.

3. Which graph shows how the resistance of most thermistors varies with temperature?

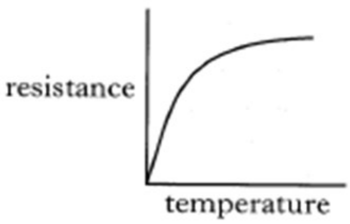
A



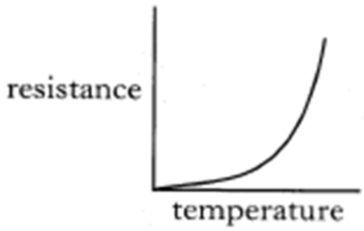
B



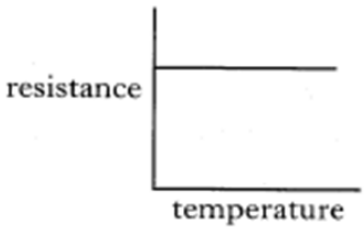
C



D

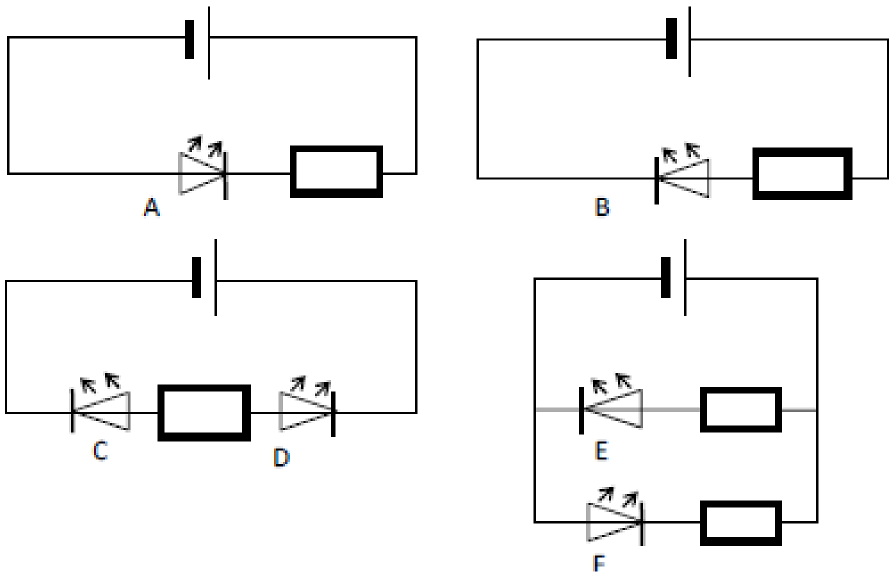


E

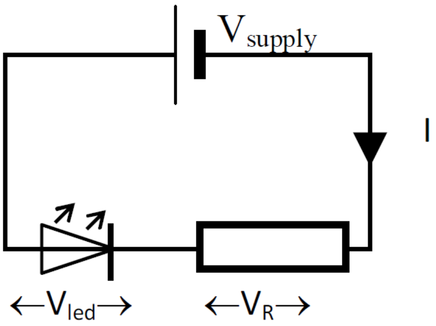


LED Circuits

1. Which of the following LED's will light?



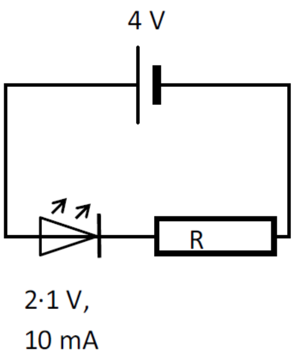
2. Find the missing values in the following table.



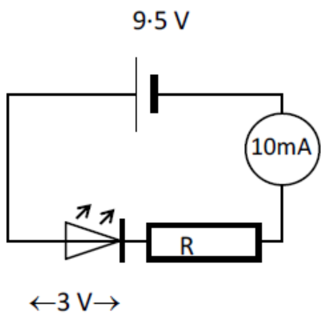
	V_{supply} (V)	*Voltage across LED* (V)	*Current* (A)	*Voltage across R* (V)	*Resistance of R* (Ω)
(a)	6	2·0	0·010		
(b)	12	2·0	0·010		
(c)	8	1·8	0·016		
(d)	20	1·6	0·008		
(e)	4	1·5	0·020		
(f)	11	2·0	0·012		

3. For each of the following circuits calculate the value of the series resistor which will enable the LED to operate at its ideal voltage and current.

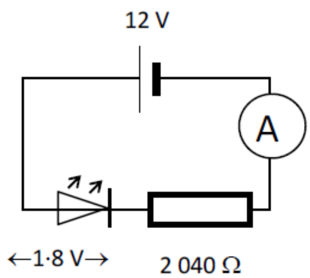
(*a*)



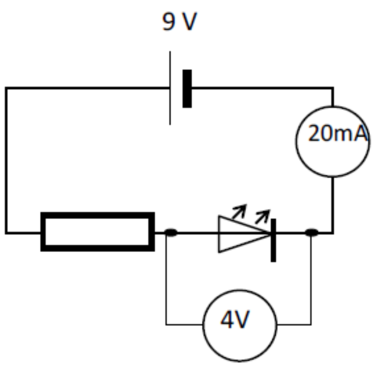
(*b*)



4. Calculate the ammeter reading in the circuit to the right.

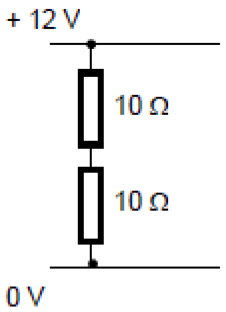


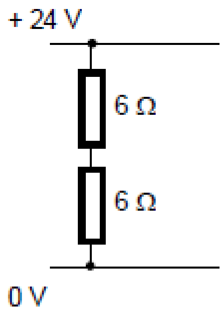
5. Calculate the value of resistor R in the circuit to the right.

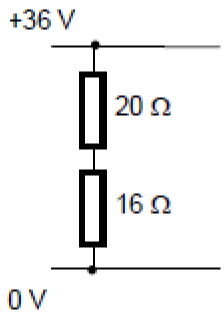


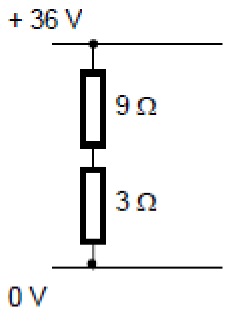
Potential Dividers

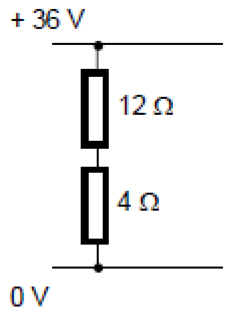
1. Find the potential difference across each resistor in the following circuits:

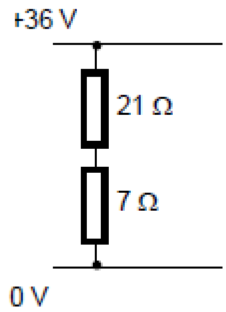
(a)


(b)


(c)


(d)


(e)


(f)


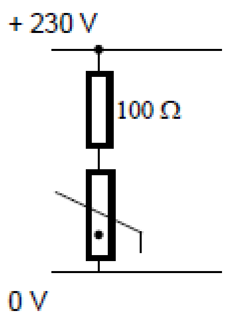
2. The tables below show how the resistances of a certain LDR and thermistor vary with external conditions.

LDR

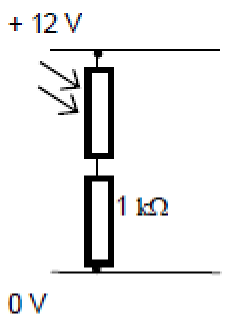
light condition	*resistance (Ω)*
dark	10 000
light	2 500
bright	20

Thermistor

temperature (°C)	*resistance (Ω)*
10	4 000
40	1 980
100	200



(a) The following circuit is part of the input to an electronic frost alarm. Calculate the potential difference across the thermistor when it is
(i) 10 °C
(ii) 40 °C



(b). The following circuit could be part of a light meter for a camera. Use the information above to find the potential difference across the LDR when it is:
(i) dark
(ii) light

Transistors

1. Draw the symbol for the npn transistor and label each terminal.

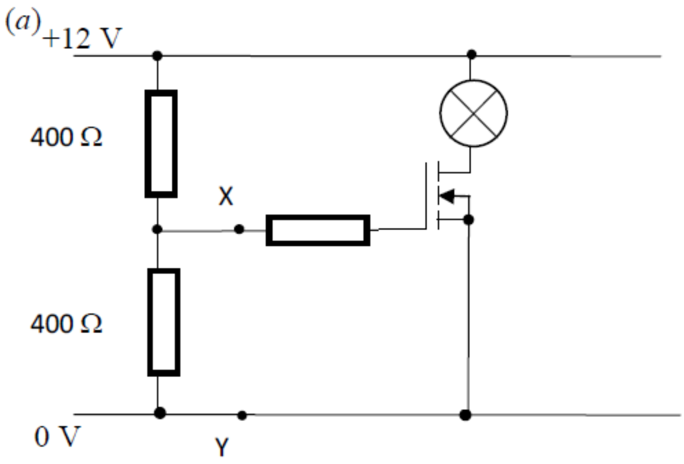
2. What does MOSFET stand for?

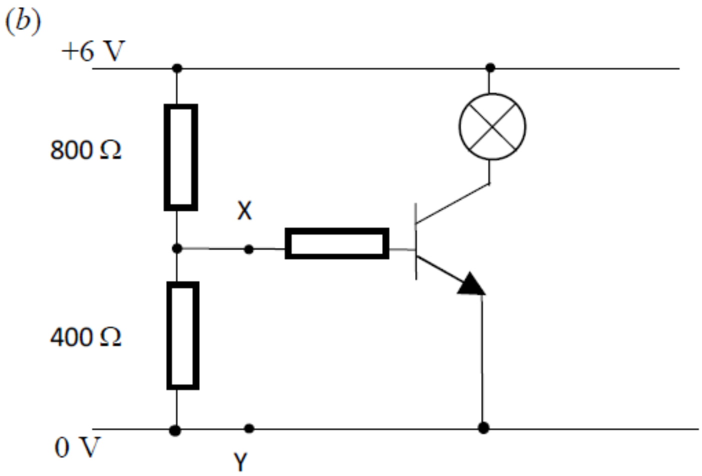
3. Draw the symbol for the n-channel enhancement MOSFET and label each terminal.

4. Transistors can be used as switches that are controlled by a voltage.
   (a) State the switching voltage for the npn transistor.
   (b) State the switching voltage for the n-channel enhancement MOSFET.

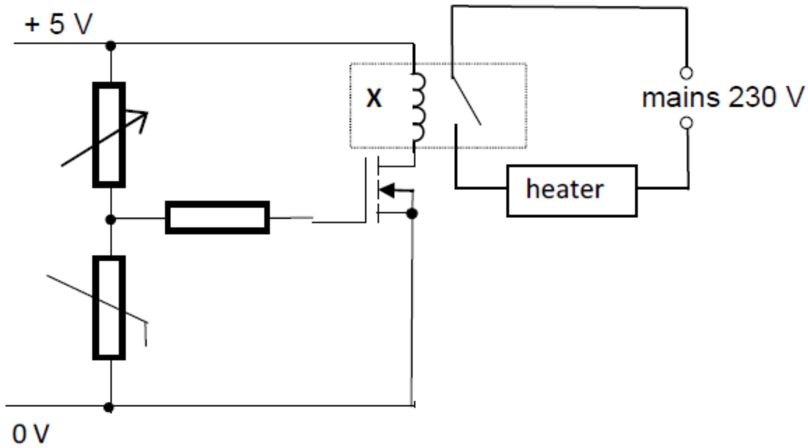
5. The "switching voltage" between which terminal on a:
   (a) npn transistor
   (b) MOSFET

6. For each of the following circuits calculate the potential difference across XY and then state whether the output device is ON or OFF.



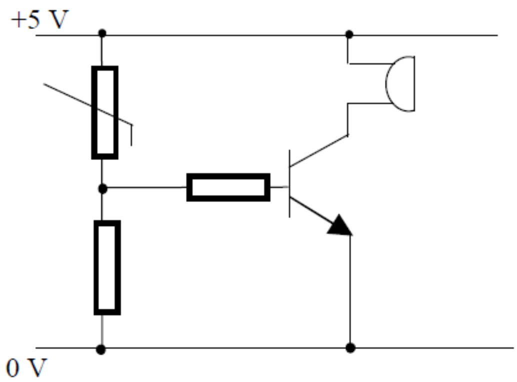


7. The following circuit is used to switch on an electric heater automatically when the temperature in a room falls below a certain value.

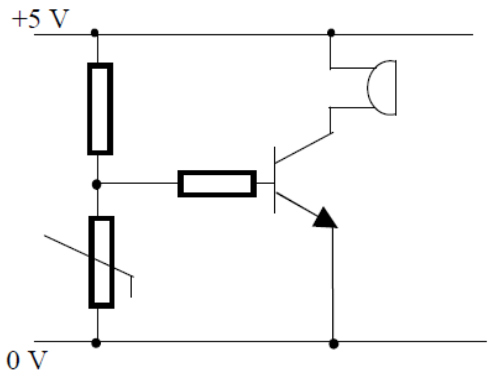


(*a*) Explain how the circuit operates.
(*b*) What would be the effect of decreasing the resistance of the variable resistor?
(*c*) Why would it be unsuitable to put the heater at point X instead of the relay?

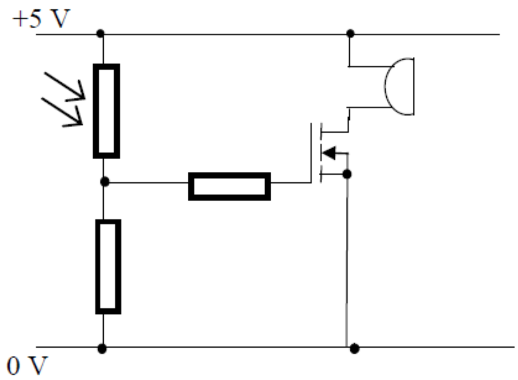
8. Study the four circuits shown below.



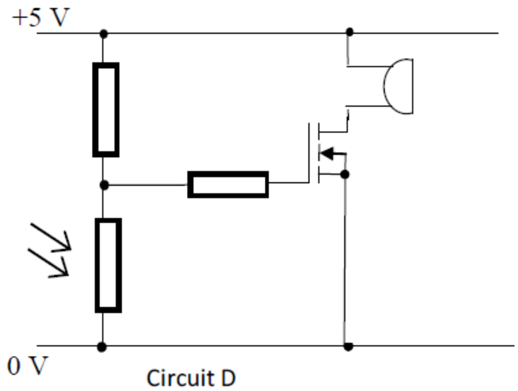
Circuit A



Circuit B



Circuit C



Circuit D

(a) Which circuit could be used to remind drivers at night to put on their headlamps? Explain your answer.
(b) Which circuit would be useful as a warning indicator of low temperature in an elderly person's house? Explain your answer.
(c) Which circuit could be used to waken campers when daylight arrives? Explain your answer.
(d) Which circuit would be most suitable as a fire alarm?

Electrical Power

1. (a) If an electric current is passed through a conducting wire, what energy transformation takes place?
   (b) Many electrical appliances in the home are designed to make use of this energy transformation. Name four of these appliances.

2. A light bulb has a power rating of 60 W.
   (a) How much electrical energy is transformed by the bulb in 1 s?
   (b) State the energy change in the lamp when it is switched on.

3. The electric motor on a ceiling fan uses 207 kJ of electrical energy in 30 minutes.
   (a) Calculate the power rating of the motor in the fan.
   (b) State the energy change in the ceiling fan when it is switched on.

4. How much electrical energy is used by the following appliances?
   (a) A 400 W drill used for 45 s
   (b) An 800 W iron used for 40 minutes
   (c) A 2.4 kW kettle that takes 5 minutes to boil the water inside it.

5. How long would a 2 kW electric kettle take to boil the water inside if it uses 100 kJ of electrical energy?

6. Find the missing values in the following table.

	***Power* (W)**	***Current* (A)**	***Voltage* (V)**
(a)		2·5	12
(b)		0·6	9
(c)	$1{\cdot}5 \times 10^{3}$		230
(d)	36		12
(e)	0·624	$2{\cdot}6 \times 10^{-3}$	
(f)	1·5	0·25	

7. (a) Draw a circuit diagram to show how you would measure the power output of a lamp bulb using a voltmeter and ammeter.
   (b) If the meter readings were 6 V and 600 mA, what would be the power of the lamp?
   (c) How much energy would this lamp use in 1 hour?

8. A colour television set is rated at 300 W.
   (a) Calculate the current drawn by the television when connected to the 230 V mains supply.
   (b) How much energy would this television use if it was left on overnight for 8 hours?

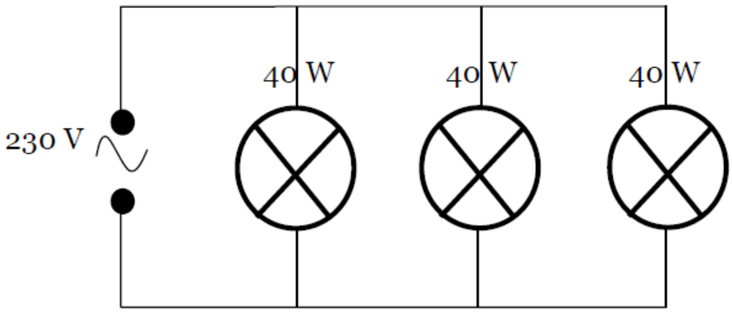
9. What is the power rating of a microwave that has a current of 3.3 A flowing through it when it is plugged in to the mains?

10. What is the current flowing through 0.1 MW food mixer that is connected to the mains?

11. What is the voltage across a 6 W light bulb that has a current of 500 mA flowing through it?

12. Three 40 W light bulbs are connected in parallel with the mains power supply, as shown.

What is the current drawn from the mains?



13. (a) Using the equations V = IR and P = VI, show that if a current I flows through a heating element of resistance R, the power of the heater is given by $P = I^2R$.
(b) What is power rating of a 30 Ω heating element when 8 A passes through it?

14. Calculate the power rating of the following devices in a car:
(a) A radio of resistance 6 Ω drawing a current of 2 A.
(b) the rear window heater of resistance 3 Ω drawing a current of 4 A.

15. An electric fire is rated at 2 kW, 230 V.
(a) What is the current in the heating element when it is switched on?
(b) Calculate the resistance of the heating element.

16. Calculate the resistance of a hairdryer element which has a power rating of 960 W when drawing a current of 4 A.

17. By combining the equations V = IR and P = VI, show that the power can also be given by $P = V^2/R$

.

18. Calculate the power rating of a heater which has a resistance of 53 Ω working off the mains voltage of 230 V.

19. The fuses used in electrical plugs in the UK come in 2 main sizes - 3 A and 13 A.
(a) What is the purpose of the fuse in the plug connected to an appliance?
(b) What energy change does a fuse depend on to work correctly?
(c) Complete the table below and select which of the above fuses would be most suitable for each of the appliances.

Appliance	Power	Voltage (V)	Current (A)	Most suitable fuse
Food Mixer		230	0.3	
Lamp	100 W	230		
Heater	2.5 kW	230		
Hi-fi unit		230	1.5	

20. A current of 6 A flows along a flex of total resistance 0.2 Ω to an electric heater which has an element of resistance 60 Ω.
    (a) Calculate the heat generated each second in
        i) the flex
        ii) the element.
    (b) i) What energy change is taking place in both the flex and the element?
        ii) Why does the element become hot and the wire remain cool?
    (c) i) What size of fuse, 3 A or 13 A, should be fitted to the plug connected to this heater?
        ii) Explain what would happen if the wrong fuse was fitted to the plug.

Heat and Specific Heat Capacity

1. Convert the following into kg:
   (a) 200 g (b) 12 g (c) 3.5 g (d) 0.24 g (e) 0.05 g (f) 36mg (g) 7.5mg

2. What is the difference between heat and temperature?

3. What is meant by the following statement: "The specific heat capacity of water is 4180 J kg^{-1} °C^{-1}."?

4. Copy and complete this table.

	Heat Energy J	Specific Heat Capacity J kg^{-1} °C^{-1}	Mass kg	Change in Temperature °C
(a)		2350	2.0	10
(b)		902	5.0	25
(c)	36 900		4.5	2
(d)	6885		0.75	34
(e)	10 080	2100		12
(f)	105 600	480		40

5. 10000 J of energy raises the temperature of 1 kg of liquid by 2 °C. How much energy will be required to raise the temperature of 4 kg of the liquid by 1 °C?

6. The specific heat capacity of concrete is about 800 J/kg°C. How much heat is stored in a storage heater containing 50 kg of concrete when it is heated through 100 °C?

7. 1.344 MJ of heat energy are used to heat water from 20 °C to 100 °C. Calculate the mass of water if the specific heat capacity of water is 4200 J/kg°C.

8. 9600 J of heat energy is supplied to 1 kg of methylated spirit in a polystyrene cup. Calculate the rise in temperature produced.
   (specific heat capacity of methylated spirit is 2300 J/kg°C)

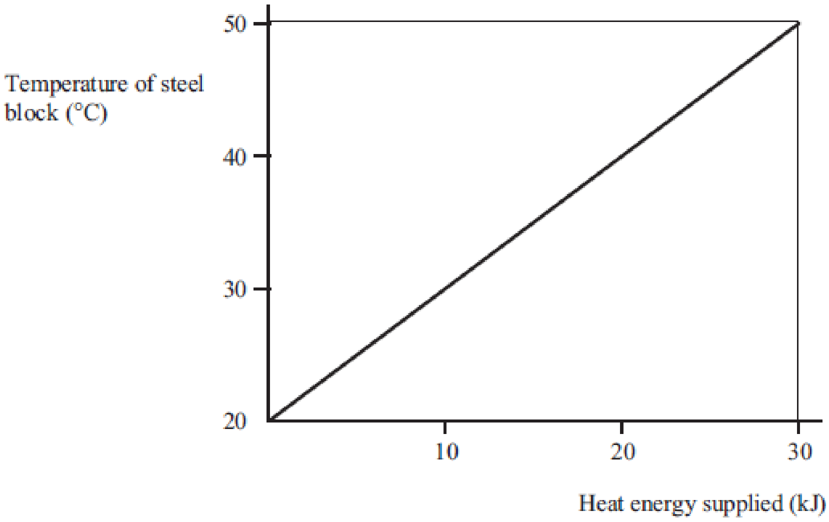
9. When 4.0 x 10^{4} J of heat is supplied to 4 kg of paraffin at 10 °C in a container the temperature increases to 14 °C.
   (a) Calculate the specific heat capacity of the paraffin.
   (b) Explain why the result in part a) is different from the theoretical value of 2200 J/kg°C.

10. If a kettle containing 2 kg of water cools from 40 °C to 25 °C, calculate the heat given out by the water.

11. The temperature of a 0.8 kg metal block is raised from 27 °C to 77 °C when 4200 J of energy is supplied. Find the specific heat capacity of the metal.

12. The tip of a soldering iron is made of copper with a mass of 30 g. Calculate how much heat energy is required to heat up the tip of a soldering iron by 400 °C. (specific heat capacity of copper is 380 J/kg°C)

13. The graph represents how the temperature of a 2 kg steel block changes as heat energy is supplied. From the graph calculate the specific heat capacity of the steel.



Latent Heat

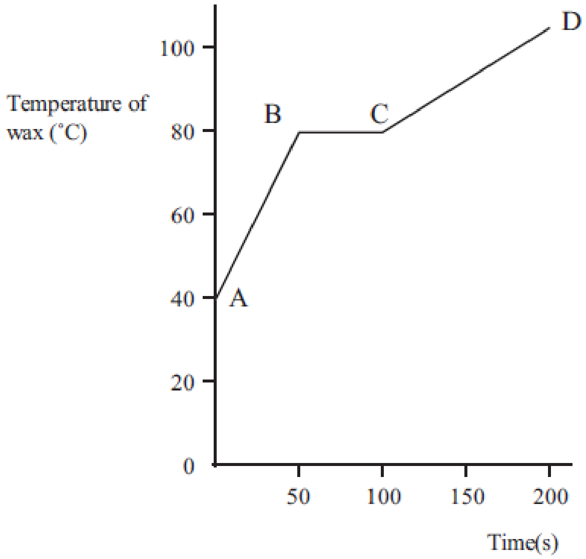
1. Calculate the amount of heat energy required to melt 0.3 kg of ice at 0 °C. (Specific latent heat of fusion of ice is 3.34×10^5 J/kg)

2. Calculate the specific latent heat of fusion of naphthalene given that 6×10^5 J of heat are given out when 4.0 kg of naphthalene at its melting point changes to a solid.

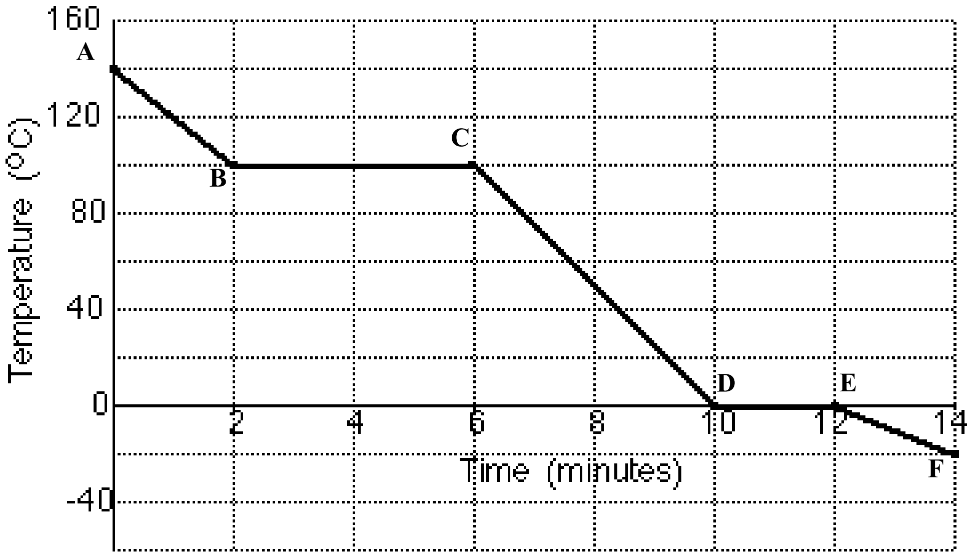
3. Calculate what mass of water can be changed to steam if 10.6 kJ of heat energy is supplied to the water at 100 °C.
(Specific latent heat of vaporisation of water is 2.26×10^6 J/kg)

4. Ammonia is vaporised in order to freeze an ice rink.
   (a) Find out how much heat it would take to vaporise 1 g of ammonia.
   (b) Assuming this heat is taken from water at 0 °C, find the mass of water frozen for every gram of ammonia vaporised.
   (Specific latent heat of vaporisation of ammonia is 1.34×10^6 J/kg
   Specific latent heat of fusion of ice is 3.34×10^5 J/kg).

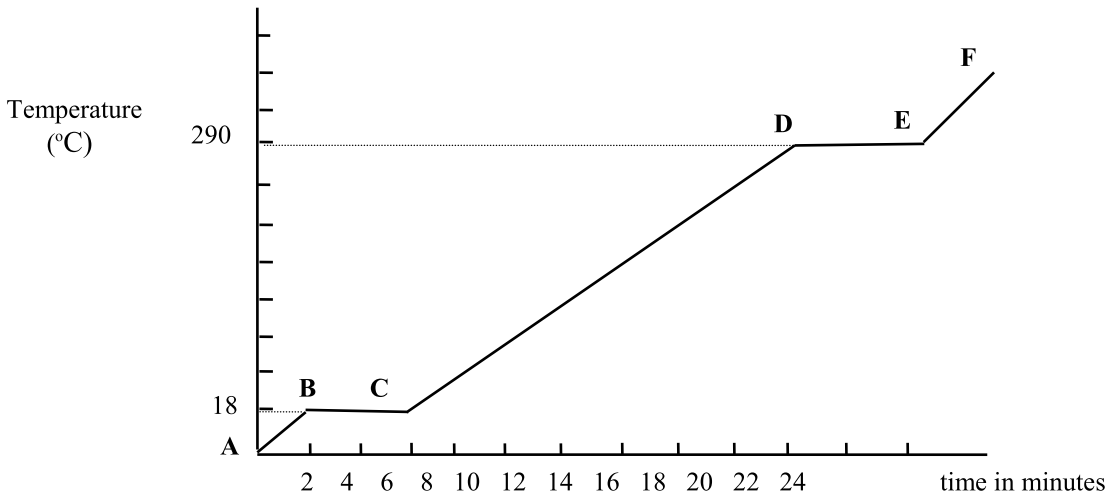
5. The graph below shows how the temperature of a 2 kg lump of solid wax varies with time when heated.
   (a) Explain what is happening to the wax in the regions AB, BC and CD.
   (b) If a 200 W heater was used to heat the wax, calculate the specific latent heat of fusion of the solid wax.



6. During an experiment 0·02 kg of steam was converted to ice. The temperature was recorded at various times throughout the experiment and plotted on a graph. The graph of results is shown below.
   (a) Between which 2 letters on the graph is the steam changing to water?
   (b) How much heat energy does the steam lose at 100 °C to become water at 100 °C?
   (c) How much heat energy does the water lose at 100 °C to become water at 0 °C?
   (d) How much heat energy does the water at 0 °C lose to become ice?



7. A sample of solid glycerol is heated and the temperature recorded over a period of time. The graph of results is drawn below.



(a) Use the letters on the graph to explain what is happening to the glycerol as it is heated.
(b) Calculate the mass of liquid glycerol produced at 18 °C given that the solid glycerol absorbed 1×5 x 10^5 J of heat.
(c) What is the boiling point of the glycerol?

Principle of Conservation of Energy

1. If an immersion heater heats 300 g of water for 2 minutes and the temperature rises by 30°C, find the power rating of the heater in watts.

2. A 350 W element is used to boil 300 g of water in a cup. The initial temperature of the water is 20 °C.
   (a) How long will it take to reach 100 °C?
   (b) State any assumptions made.

3. Meteors are small pieces of matter made mostly of iron. Few meteors hit the surface of the Earth because of the Earth's atmosphere. Assuming all the kinetic energy of the meteor changes to heat energy in the meteor, if a 0.001 kg meteor travelling at 30000 m/s crashes into the Earth's atmosphere resulting in a change in temperature of 20000 °C, calculate the specific heat capacity of the iron.

4. If a copper ball is dropped on a hard surface the ball is deformed, and we can assume all the kinetic energy is transferred to internal energy in the ball. From what height must the ball be dropped to raise its temperature by 2 °C?
   (Specific heat capacity of copper is 380 J/kg°C)

5. An electric shower has a 1.5 kW heating element.
   (a) How much heat energy can it give out in five minutes?
   (b) If the element is used to heat 5 kg of water for 5 minutes, what would be the rise in temperature? (Specific heat capacity of water is 4200 J/kg).

6. A heating coil carries an electrical current of 2 A for 100 s at a voltage of 20 V. If this is sufficient to boil away 20 g of liquid nitrogen at its boiling point, what is the specific latent heat of vaporisation of nitrogen?

7. A pupil put 2 litres of water at 20 °C into her 1000 W kettle. She switched it on and then forgot it for 15 minutes. Unfortunately, it did not have an automatic cut-out and when she came back the kitchen was full of steam. 1 litre of water has a mass of 1 kg.
(a) How much energy was required to bring the water to boiling point?
(b) How much electrical energy had been used altogether?
(c) How much water had been turned into steam?
(d) Which of your answers are approximate and why?

8. A 200 g bun is put in a 600 W microwave oven for one minute. If its temperature rises from 15 °C to 45 °C, what is the specific heat capacity of the bun?

9. A heat shield on a spacecraft has a mass of 70 kg. The spacecraft is travelling at 900 m/s. On re-entry into the Earth's atmosphere, the velocity of the spacecraft is reduced to 250 m/s.
(a) Calculate the change in kinetic energy of the heat shield.
(b) The heat shield ihas a specific heat capacity of 980 J/kg^{o}C. Calculate the change in temperature of the heat shield.
(c) What causes the change in temperature calculated?

Pressure

1. *Convert the following into m^2:*
(a) 60 cm x 40 cm *(b) 150 cm^2* *(c) 120 mm x 150 mm*
(d) 25 mm^2 *(e) 0.5mm^2*

2. What is the meaning of the term 'pressure' in terms of force and area?

3. Copy and complete this table:

	Pressure / Pa	Force / N	Area / m^2
(a)		120	1.6
(b)		4000	0.5
(c)	1.1 x 10^5		2.0
(d)	9000		8.0 x 10^{-2}
(e)	12 000	7.2 x 10^5	
(f)	1.4 x 10^4	4.9 x 10^4	

4. Find the pressure exerted in each of the following cases;
(a) a force of 240 N acting on an area of 4.0 m^2.
(b) a force of 500 kN acting on an area of 1.25 m^2.
(c) a force of 125 N acting on an area measuring 40 cm by 25 cm.
(d) a force of 64 N acting on a circular area of radius 12 cm.

5. Liam has a mass of 65 kg and each of his shoes has an area of 0.025 m^2.
What pressure does he exert on the ground?

6. A camel has a mass of 500 kg and each foot has an area of 0.1 m^2.
What pressure does the camel exert on the ground?

7. Explain why the use of large tyres helps prevent a tractor from sinking into soft ground.

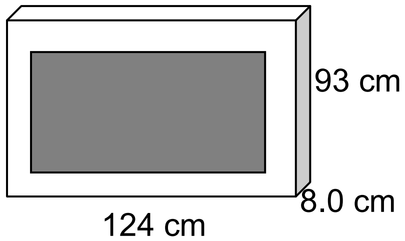
8. Calculate the force in each of the following:
   (a) a pressure of 1200 Pa acting on an area of 2.4 m^2.
   (b) a pressure of 100 000 Pa acting on an area of 2.4 m^2.
   (c) a pressure of 240 kPa acting on a surface measuring 25 cm by 12 cm.
   (b) a pressure of 4.8 x 10^7 Pa acting on an area of 160 mm^2.

9. Calculate the area over which the force is distributed in each of the following:
   (a) a force of 60 N causing a pressure of 960 Pa.
   (b) a force of 4000 N causing a pressure of 840 Pa.
   (c) a force of 15 N causing a pressure of 2.25 x 10^7 Pa.

10. A 480 g tin of baked beans is a cylinder with a radius of 3.2 cm. It is placed on a kitchen counter. What is the pressure on the counter caused by the tin?

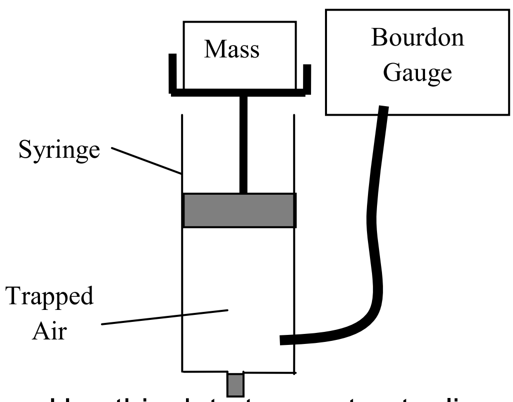
11. A car of mass 1250 kg is driven on to a bridge. The pressure on the surface of the bridge when all four tyres are on the ground is 39.0 kPa. What is the contact area of one tyre on the bridge?

12. A television has a length of 124 cm, a height of 93 cm and a depth of 7.0 cm.
    If it has a mass of 30 kg, what is the:
    (a) Maximum pressure that the television can exert on a surface?
    (b) Minimum pressure that the television can exert on a surface?



13. Are you more likely to fall through an icy lake if you are on your tip toes or lying flat on your back with your arms and legs stretched out? Explain your answer.

14. In an experiment, a mass of 100 g (which has a weight of 1 N) is placed on top of a syringe filled with trapped air. A Bourdon Gauge is used to measure the air pressure inside the syringe. This is then repeated for different masses. The results are given in the table.



Force / N	Pressure / x 10^5 Pa
0	1.01
1	1.03
2	1.05
3	1.07
4	1.09
5	1.11

Use this data to construct a line graph of force against change in pressure, and use the gradient of the straight line to calculate the surface area of the syringe plunger inside the syringe.

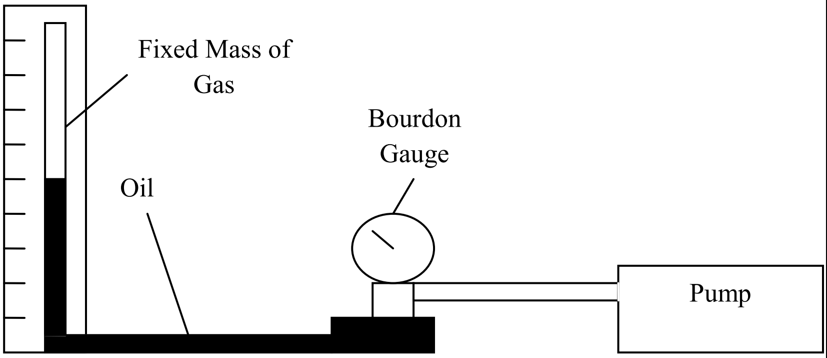
Kinetic Theory

1. Explain, using the kinetic theory of particles, what happens to the particles in a liquid when it melts and becomes a gas.

2. Explain, using kinetic theory, how the air in a bicycle tyre creates pressure on the inside surface of the tyre.

3. Convert the following into m^3:
   (a) 25 cm x 12 cm x 20 cm　　(b) 480 cm^3
   (c) 40 mm x 50 mm x 60 mm　　(d) 25 mm^3

4. In an experiment, the volume of a fixed mass of gas is decreased by trapping the gas at the top of a glass tube with a quantity of oil and then using a pump to push the oil up the tube.
   The pressure of the gas is measured with a Bourdon gauge and the volume of gas is measured using a calibrated scale next to the glass tube. The results are shown.



Volume / cm^3	Pressure / x 10^5 Pa
1.5	1.57
1.6	1.48
1.7	1.39
1.8	1.31
1.9	1.24
2.0	1.18

   (a) Using the data, draw a line graph of volume against 1 / pressure.
   (b) What does this graph tell you about the relationship between the volume and pressure of a fixed mass of gas?
   (c) Explain this relationship in terms of the kinetic theory of particles.

5. Explain, using the appropriate gas law, why a balloon will burst if you squeeze it.

6. A cylinder contains 0.48 m^3 of gas at a pressure of 80 000 Pa. What is the volume of the gas when the pressure is:
   (a) 50 000 Pa　　(b) 100 000 Pa　　(c) 120 000 Pa

7. A 5 cm^3 syringe is filled with air and the pressure of the air is found to be 1.01 x 10^5 Pa. The syringe plunger is then pushed until there is 3 cm^3 of air. What is the new air pressure?

8 A container holds 2.4 m^3 of gas at a pressure of 120 000 Pa. What is the pressure when the volume of the container is reduced to 2.0 m^3.

9. A sealed balloon contains 60 m^3 of gas at a pressure of 105 000 Pa. What is the volume of the balloon when the pressure has increased to 140 000 Pa?

10. A syringe contains 60 m^3 of gas at atmospheric pressure (100 000 Pa). What is the pressure in the syringe when the volume is changed to:
   (a) 80 cm^3　　(b) 150 cm^3　　(c) 200 cm^3

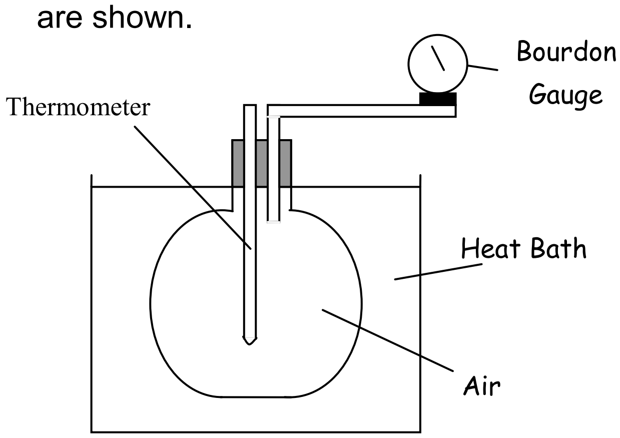
11. A diver breathes out an air bubble at a depth of 40 m where the air pressure is 500 000 Pa. The radius of the bubble is 4.0 cm. What is the radius of the bubble when it is just about to break the surface?

12. Convert the following temperatures from Celsius (°C) to Kelvin (K):
(a) 20 °C (b) 27 °C (C) 120 °C (d) -53 °C

13. Convert the following temperatures from Kelvin (K) to Celsius (°C):
(a) 353 K (b) 300 K (C) 200 K (d) 60 K

14. The temperature of a liquid rises from 150 K to 320 K. Express the temperature rise in K and in °C.

15. A conical flask is sealed with air inside, and is placed in a heat bath. The temperature of the gas increases from 20 °C to 70°C. After every 10 °C temperature increase, the pressure of the gas is measured using a Bourdon gauge. The results are shown.



Temperature / °C	Pressure / x 10^5 Pa
20	1.01
30	1.04
40	1.08
50	1.11
60	1.15
70	1.18

(a) Using the data, draw a line graph of pressure against temperature (in degrees Celsius). Make sure that your temperature axis goes from -300 °C to 70 °C.
(b) On your graph from part (a), continue your straight line back until it crosses through the x- axis. At what temperature is the pressure of the gas zero?
(c) Using the data, draw a line graph of pressure against temperature (in Kelvin).
(d) What do these two graphs tell you about the relationship between the pressure and temperature of a fixed mass of gas?
(e) Explain this relationship in terms of the kinetic theory of particles.

16. Explain, using the appropriate gas law, why it is important that car tyres are not filled up with so much air that the air pressure is above the car manufacturer's guidelines?

17 A cylinder contains a gas at a temperature of 27 °C and a pressure of 120 000 Pa. What is the pressure when the temperature is changed to:
(a) 77 °C (b) 54 °C (c) 102 °C (d) -23 °C

18. A sealed flask of gas at 87 °C has a pressure of 132 000 Pa. What is the temperature in °C when the pressure is:
(a) 120 000 Pa (b) 66 000 Pa (c) 200 000 Pa

19. The maximum safe pressure inside a diver's air cylinder is 232 bar. If the cylinder is filled to a pressure of 225 bar when the gas temperature is 37 °C, what is the maximum temperature the cylinder should be allowed to reach?

20. When a diver's cylinder is filled the initial pressure is 232 bar (232 times atmospheric pressure) and the gas inside is warm. After cooling to 150 °C, the pressure in the cylinder is found to have dropped to 207 bar. What was the temperature of the air in the cylinder immediately after filling.

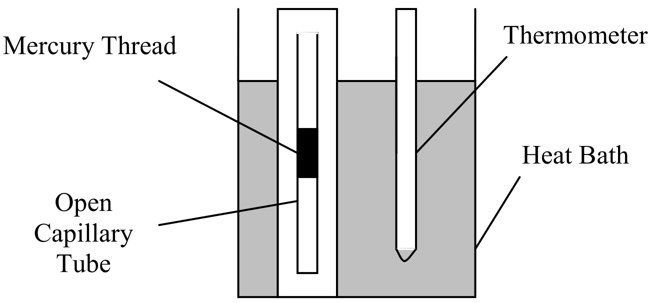
21. A gas cylinder has a safety valve which will operate if the pressure of the gas reaches 2.5 x 10^3 Pa. The cylinder is filled with a gas at a temperature of 25 °C. If the safety valve operates when the temperature of the gas has reached 42 °C, what was the initial pressure of the gas?

22. Explain why temperatures below absolute zero are not possible.

23. At a temperature of 20 °C, the pressure of a fixed mass of gas in a sealed container is found to be 104 kPa. The gas is heated to a uniform temperature of 90 °C using a heat bath.
What is the pressure of the gas at a temperature of 90 °C?

24. The pressure of the air in a lorry tyre is found to be 2.58 x 10^5 Pa at the end of a journey. Once the tyre has cooled down, the temperature of the air inside the tyre is found to be 10 °C with the pressure decreasing to 2.41 x 10^5 Pa.
What was the temperature of the air in the tyre at the end of the journey? Give your answer in degrees Celsius.

25. In an experiment, an open capillary tube with a mercury thread is placed in to a heat bath.
As the temperature of the gas increases, the mercury thread moves up the capillary tube. The pressure of the gas remains constant because the capillary tube is open. The temperature of the gas is measured with a thermometer and the volume of the gas is measured using a scale next to the open capillary tube. The results of the experiment are shown.



Temperature / °C	Volume / cm^3
20	1.50
25	1.88
30	2.25
35	2.63
40	3.00
45	3.38

(a) Using the data, draw a line graph of volume against temperature (in degrees Celsius). Make sure that your temperature axis goes from -300 °C to 45 °C.
(b) Using the data, draw a line graph of volume against temperature (in Kelvin).
(c) What do these two graphs tell you about the relationship between the volume and temperature of a fixed mass of gas?
(d) Explain this relationship in terms of the kinetic theory of particles.

26. Air is trapped in a glass capillary tube by a bead of mercury. The volume of air is found to be 0.15 cm^3 at a temperature of 27 °C.
Assuming that the pressure of the air remains constant, what is the volume of the air at a temperature of 87 °C?

27. 100 cm^3 of a fixed mass of air is at a temperature f 0 °C. At what temperature will the volume be 110 cm^3 if the pressure remains constant?

28. Air is trapped in a glass capillary tube by a bead of mercury. The volume of the air is found to be 0.10 cm^3 at a temperature of 27 °C. Calculate the volume of air at a temperature of 87 °C.

29. The volume of a fixed mass of gas at constant temperature is found to be 50 cm^3. The pressure remains constant and the temperature doubles from 20 °C to 40 °C. Explain why the new volume of the gas is not 100 cm^3.

30. The volume of a fixed mass of gas is 30.0 cm^3 at 30 °C. The temperature of the gas is increased to 60 °C without changing the pressure.
A student makes this statement:
'As the temperature of the gas has doubled, the volume of the gas will also double. Therefore, the volume of the gas at 60 °C will be 60.0 cm^3.'
(a) Explain why this statement is incorrect.
(b) Calculate what the volume of the gas would actually be at 60 °C.

31 A fixed mass of gas is trapped in to a syringe. The gas has a pressure of 1.63×10^5 Pa when it has a volume of 3.0 cm^3 and a temperature of 22 °C. The gas is then heated until it has a uniform temperature of 57 °C. What will be the pressure of the gas if the volume of the gas is increased to 5.0 cm^3?

32. A syringe contains 4800 mm^3 of gas at a temperature of 7 °C and a pressure of 116 000 Pa. What is the pressure of the gas when the volume is reduced to 3.2 cm^3 and the temperature increased to 21 °C?

33. A cylinder contains gas at a temperature of 23 °C and a pressure of 108 000 Pa. When the temperature of the gas is increased to 60 °C and the pressure reduced to 96 000 Pa the volume of the gas is found to be 9.6 cm^3. What was the original volume of the gas?

34. A sealed syringe contains 100 cm^3 of air at atmospheric pressure and a temperature of 27 °C. When the piston is depressed the volume of air is reduced to 20 cm^3 and this produced a temperature rise of 4 °C. Calculate the new pressure of the gas.

35. Use kinetic theory to explain the following:
(a) Why the pressure of a fixed volume of gas decreases as its temperature decreases.
(b) Why the pressure of a gas at a fixed temperature decreases if its volume increases.