Farr High School

NATIONAL 4 PHYSICS

Unit 1
Electricity and Energy

Question Booklet

1. Basic Electrical Components

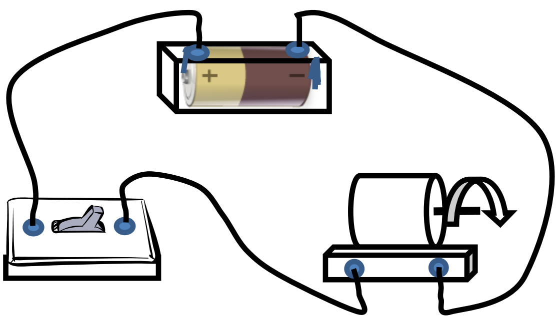
National 3 and 4

1. Find out and draw the symbol for each of the following electrical components:

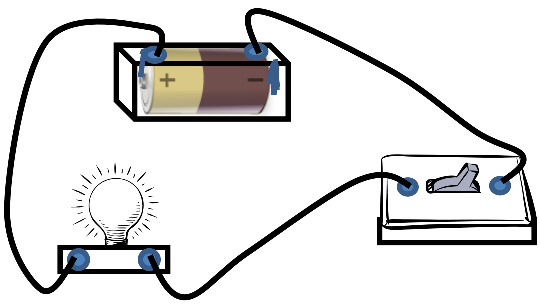
   (a) lamp
   (b) connecting lead
   (c) battery
   (d) cell
   (e) motor
   (f) resistor
   (g) switch
   (h) variable resistor
   (i) voltmeter
   (j) ammeter
   (k) fuse
   (l) buzzer
   (m) bell

2. Here are 4 pictures of circuits.
   Draw a proper circuit diagram for each one, using symbols instead of pictures.

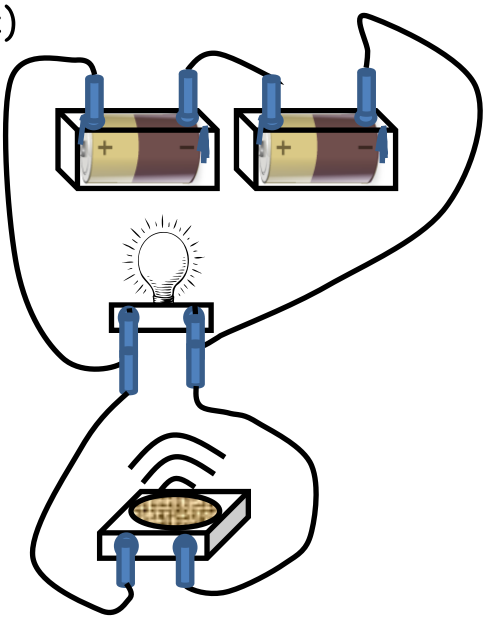
   (a)



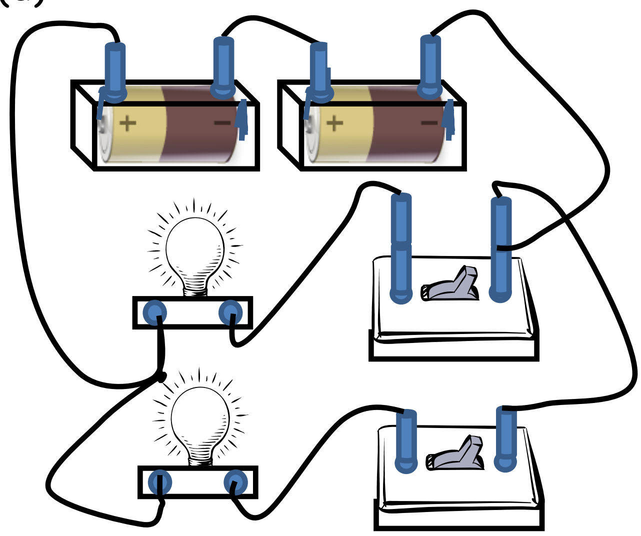
   (b)



(c)



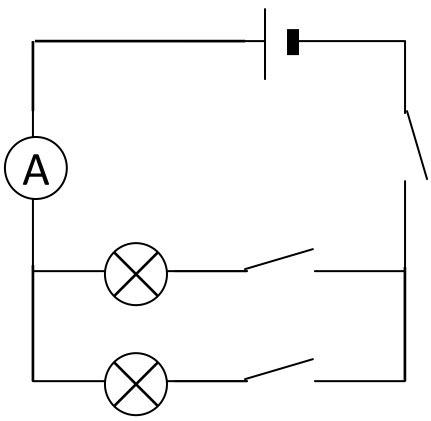
(d)



3. Draw a circuit consisting of one lamp, one switch, one battery and one buzzer, connected in series (one loop).

4. Draw a circuit that will allow 1 lamp, 1 motor and 1 buzzer to be switched on and off separately. Each component will require its own switch. The circuit should operate from 1 battery. (HINT: look at Q 2.(d) to help you)

5. Look at the following circuit:



(a) How many lamps are in the circuit?

(b) How many switches are in the circuit?

(c) What other components have been used?

2. Measuring Current, Voltage and Resistance

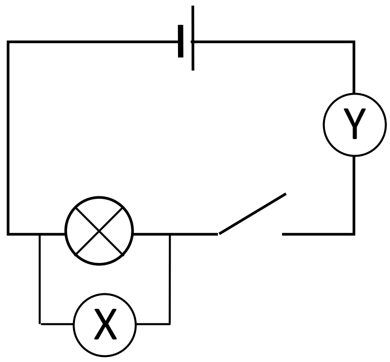
National 4

1. Draw the symbol for
   (a) an ammeter
   (b) a voltmeter
   (c) an ohmmeter

2. The **current** in a circuit tells us how fast the electricity is flowing.
   (a) What is the unit for current? (This means "what is current measured in?")
   (b) What meter do we use to measure current?

3. The **voltage** of a battery tells us how much energy the battery supplies to the charges passing through it.
   (a) What is the unit for voltage?
   (b) What meter do we use to measure voltage?

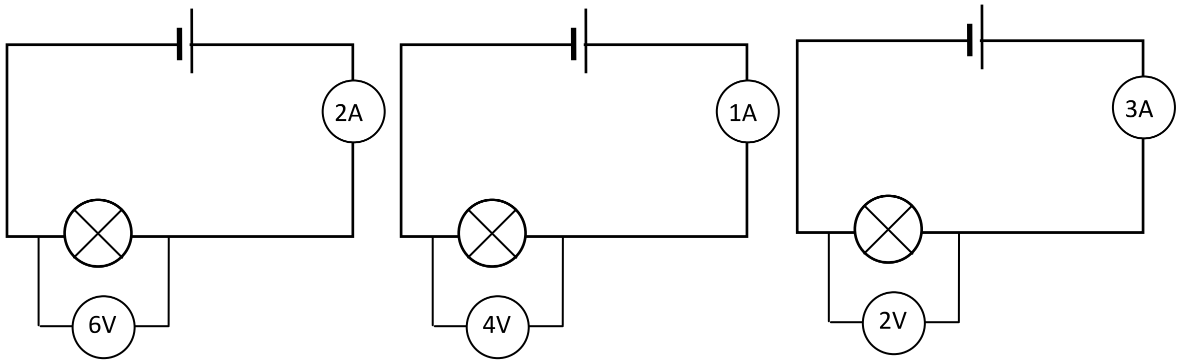
4. A student sets up a circuit, as shown below, in order to switch on a lamp.



The student wants to measure the current through the lamp and the voltage across it.

   (a) What should the student use to measure the voltage across the lamp?
   (b) What should be used to measure the current in the lamp?
   (c) Is meter X a voltmeter or an ammeter?
   (d) Is meter Y a voltmeter or an ammeter?

5. Look at the three circuits below:

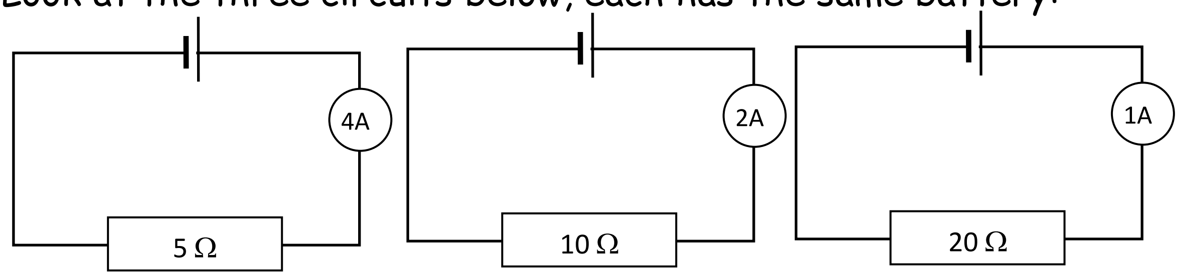


Circuit 1 **Circuit 2** **Circuit 3**

(a) Which circuit has the lowest current through the lamp?
(b) Which circuit has the lowest voltage across the lamp?
(c) In which circuit is the electricity flowing fastest?
(d) In which circuit are the charges giving most energy to the lamp?

6. The **resistance** of components in a circuit affects the size of the current flowing in the circuit.
(a) What is the unit for resistance?
(b) What meter can be used to measure resistance directly?
(c) If we increase the resistance of a circuit, what happens to the size of the current flowing?

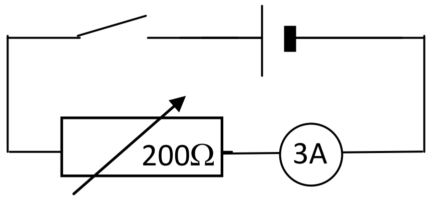
7. Look at the three circuits below, each has the same battery:



Circuit 1 **Circuit 1** **Circuit 1**

(a) Which circuit has the highest resistance?
(b) Which circuit has the lowest current?
(c) Predict what the current will be if the resistance is increased to 40 Ω.

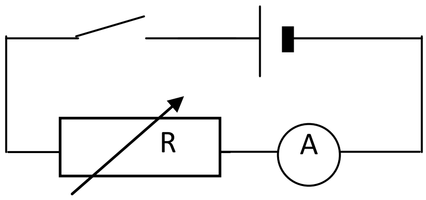
8. A **variable resistor** is a resistor that can have its resistance changed. In the following circuit the resistance is changed to make the current increase from 3A to 6A.



(a) Did the resistance increase or decrease to make the current rise to 6A?

(b) Suggest what the new resistance might be.

9. The following circuit is set up to investigate the effect of resistance on current.

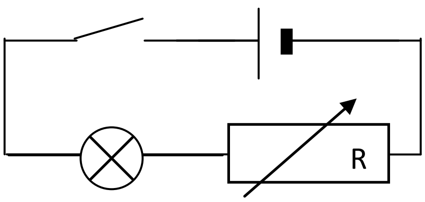


(a) Describe what happens to the ammeter reading as the resistance of the variable resistor is increased.

(b) Present the results in the following table as a line graph:

Resistance (Ω)	100	200	300	400	500
Current (A)	0.120	0.060	0.040	0.030	0.024

10. The resistance of the variable resistor, in the circuit below, is decreased.



(a) State what happens to the current in the circuit as the resistance decreases.

(b) Predict what will happen to the brightness of the lamp.

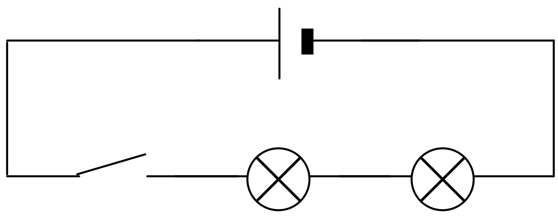
3. Types of Circuit: Series or Parallel

National 3 and 4

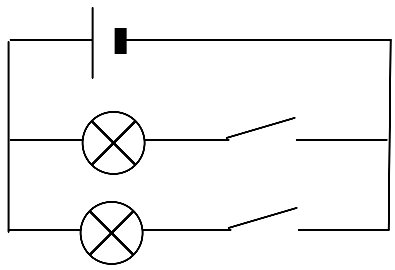
1. What type of circuit; series or parallel, has only one path from one side of the battery to the other?

2. What type of circuit; series or parallel, has more than one path from one side of the battery to the other?

3. Look at the 2 circuits below:



Series Circuit

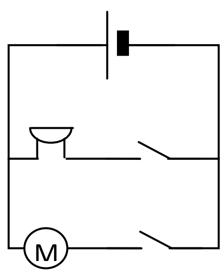


Parallel Circuit

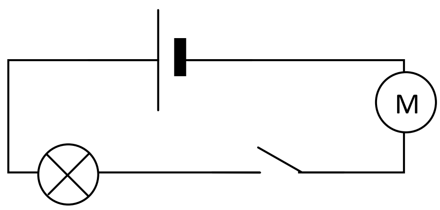
(a) In which circuit can each lamp be switched on separately?
(b) In which circuit must both lamps be on or off together?
(c) In the series circuit, if one lamp blows, can the other remain on?
(d) In the parallel circuit, if one lamp blows, can the other remain on?

4. Decide whether each of the following circuits is series or parallel:

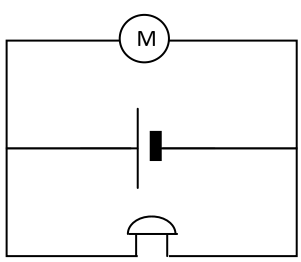
(a)



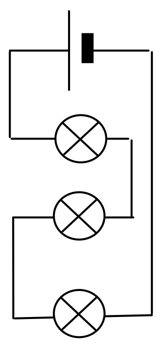
(b)



(c)



(d)



4. Current and Voltage in a Series Circuit

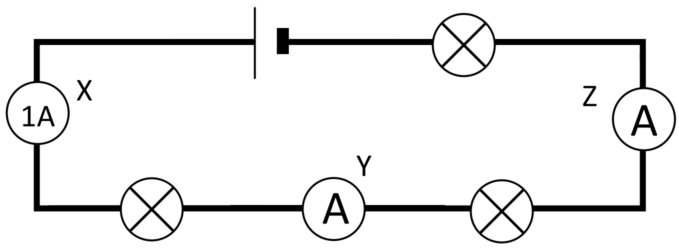
National 4

Helpful Hint

The rules for **series** circuits are:

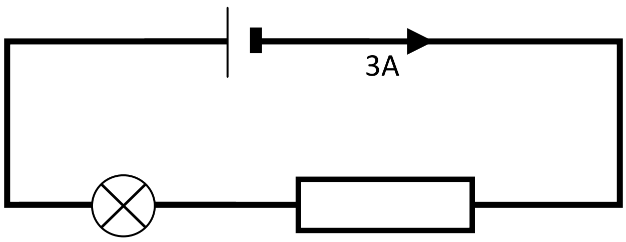
1. the **current is the same** at all points in the circuit
2. the **voltage of the supply is shared** amongst the components in the circuit.

1. In the following circuit, three lamps are connected in series. Ammeters are placed at points X, Y and Z.



The ammeter at X measures 1 amp.
What is the current measured by the ammeters at Y and Z?

2. A current of 3A flows in the circuit below:

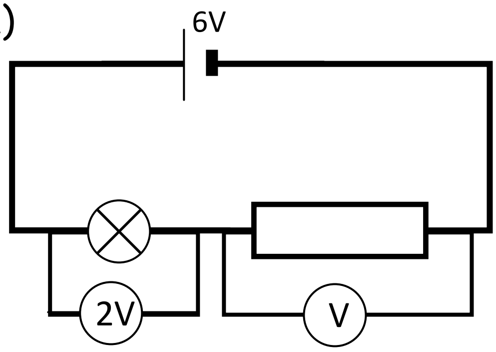


(a) What current flows in the lamp?
(b) What current flows in the resistor?

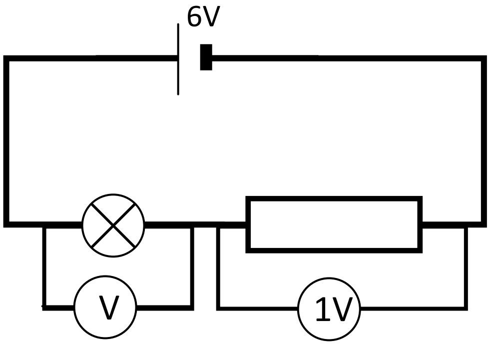
3. State the rule for current at all points in a series circuit.

4. In each of these circuits, calculate the unknown voltage.

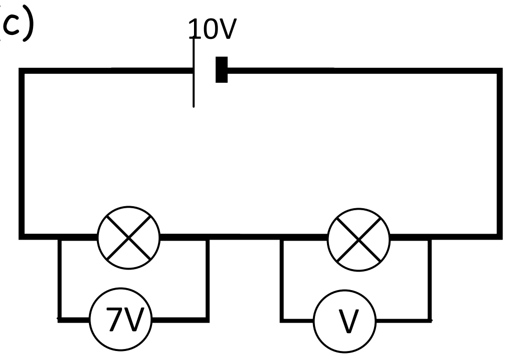
(a)



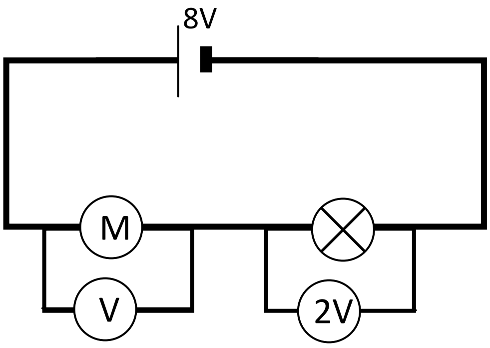
(b)



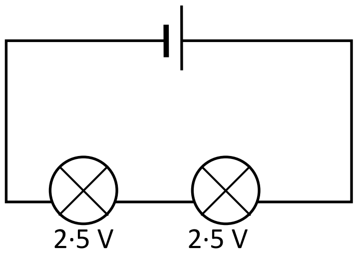
(c)



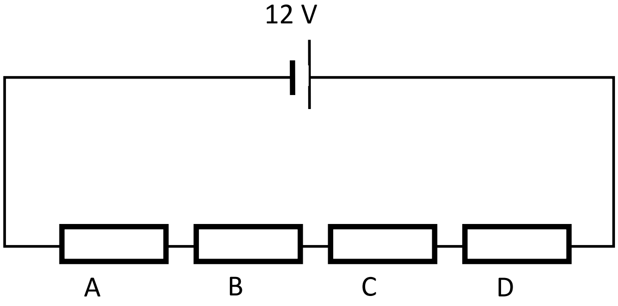
(d)



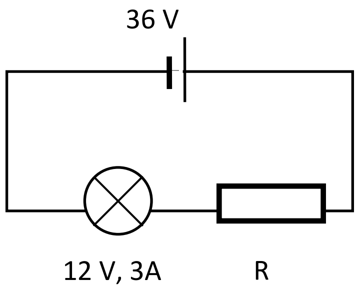
5. Two identical 2·5 V bulbs are connected to a supply as shown. What must be the voltage of the supply?



6. Four identical resistors are connected across a 12 V supply as shown in the diagram. Determine the voltage across each of the resistors.



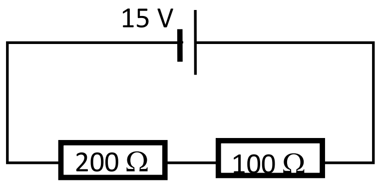
7. A simple circuit with a bulb and resistor in series is shown below.



(a) The bulb is operating at 12V and 3A.
Determine the voltage across resistor R.

(b) The current in the bulb is 3 A. Determine the current flowing in the resistor.

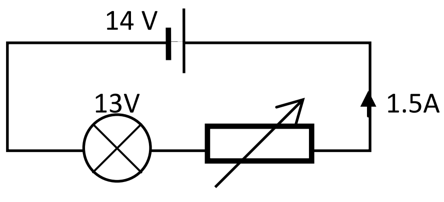
8. Two resistors are connected in series to a supply as shown in the diagram.



(a) The current in the 200 Ω resistor is 0·5 A.
Determine the current in the other resistor.

(b) The voltage across the 100 Ω resistor is 5 V.
Determine the voltage across the 200 Ω resistor.

9. A variable resistor is used as a dimmer switch in a simple series circuit as shown.

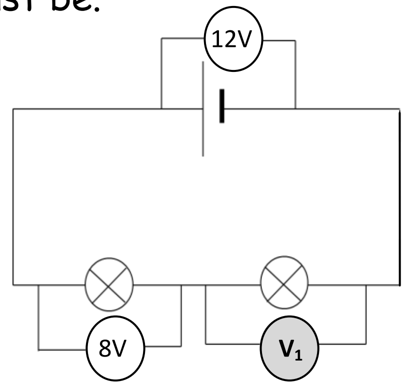


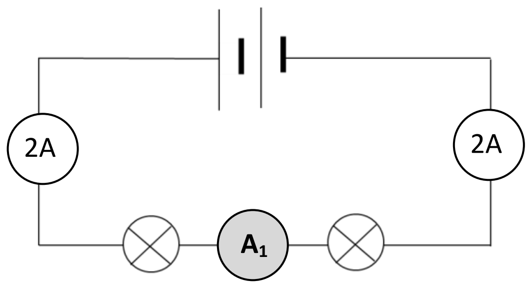
The resistor is adjusted until the bulb is shining brightly. The voltage across the bulb is 13V and the current through the resistor at this setting is 1·5 A.

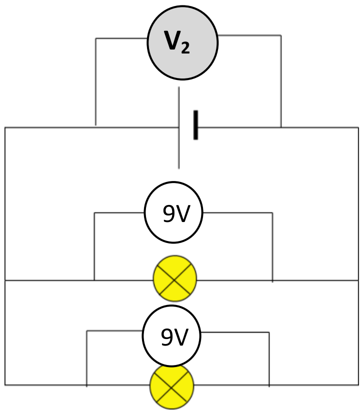
(a) Calculate the voltage across the variable resistor.

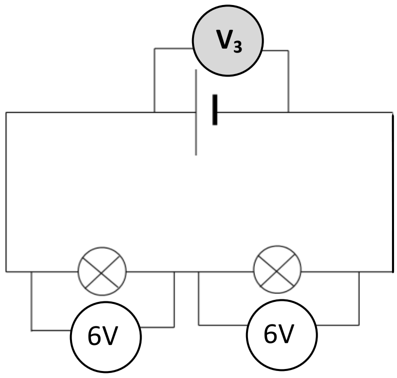
(b) Determine the current flowing in the bulb.

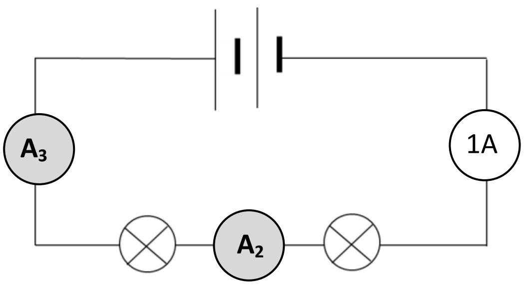
10. Look at each of the following circuits and use the circuit rules to work out what the unknown ammeter and voltmeter readings must be.

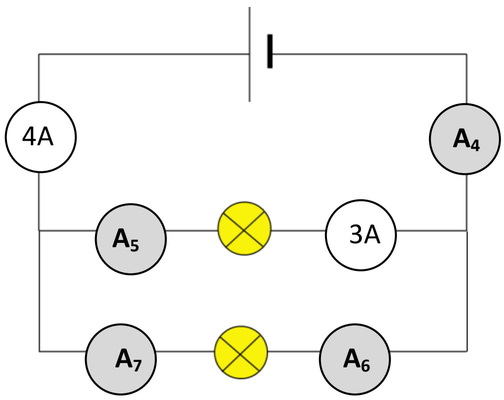


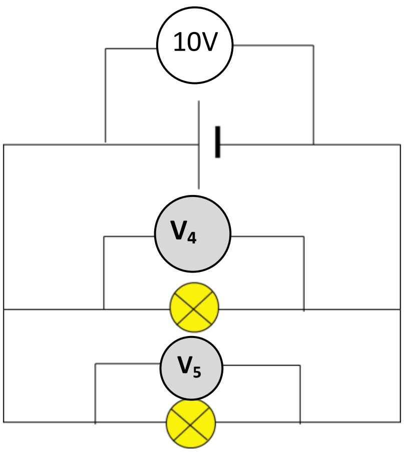


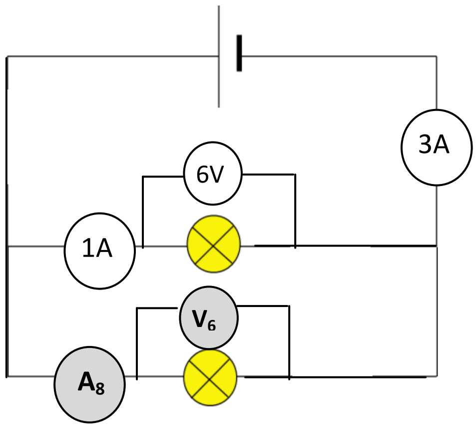












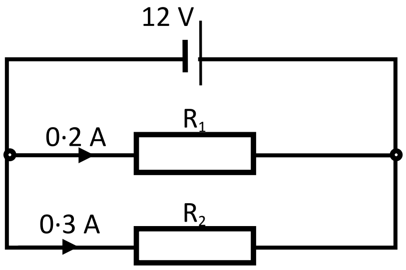
5. Current and Voltage in a Parallel Circuit

National 4 (optional extension)

Helpful Hint
The rules for **parallel** circuits are:

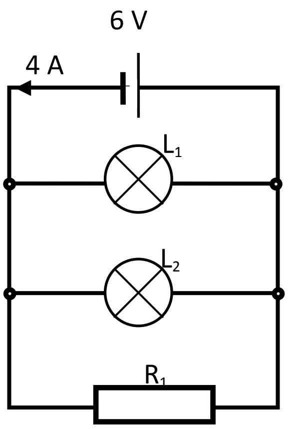
1. the **voltage is the same** across all the components in parallel.
2. the **current from the supply is shared** amongst the different branches of the circuit.

1. Two resistors are connected in parallel to a 12 V battery.



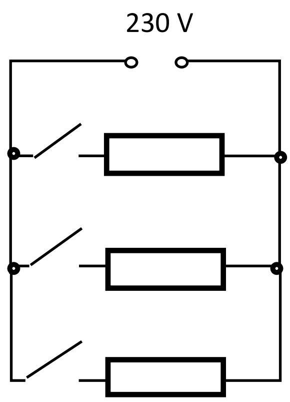
(a) Determine the voltage across R_1.
(b) Determine the voltage across R_2.
(c) Calculate the current drawn from the battery.

2. Two identical bulbs and a resistor are connected in parallel to a 6 V supply.



(a) Determine the voltage across L_2 .
(b) A current of 1·8 A flows through each of the bulbs.
Calculate the current flowing through the resistor.

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.

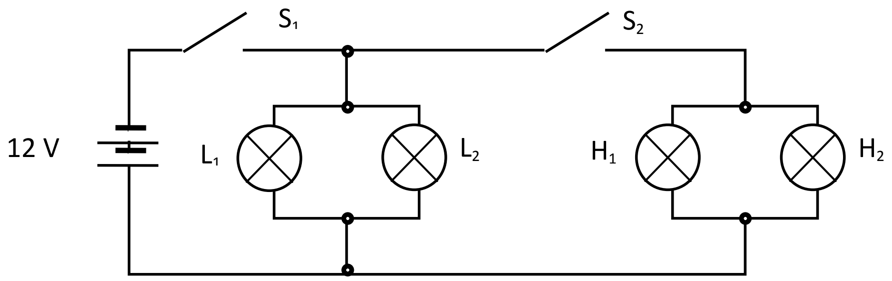


(a) Determine the voltage across the middle element.

(b) Calculate the total current flowing from the supply when two of the elements are switched on.

(c) Calculate the maximum current drawn from the mains by the fire.

4. The diagram below shows how a car's headlights 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.



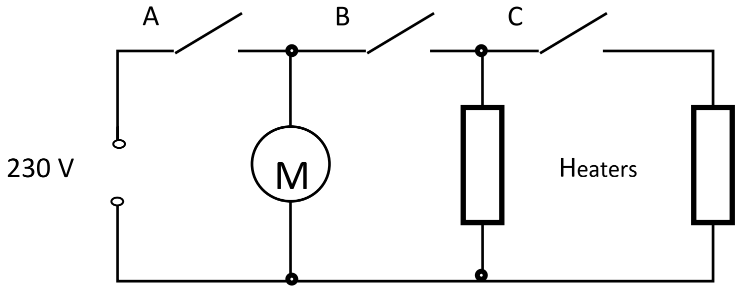
(a) Determine the voltage across the sidelight L_1.

(b) Determine the voltage across the headlight H_2.

(c) Each sidelight draws a current of 3 A from the car battery. Calculate 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. Calculate the total current drawn from the battery when S_1 and S_2 are closed.

5. A hairdryer contains a motor and heating elements (resistors). The hairdryer shown below has three heat settings- cold, warm and hot. The circuit diagram shows how these settings are achieved using switches A, B and C.



The motor draws a current of 3 A from the mains and the heating elements draw a current of 2 A each from the mains.

(a) State which switches must be closed to make the hairdryer blow warm air.

(b) Calculate the current drawn from the mains when the hairdryer blows warm air.

(c) State which switches must be closed to make the hairdryer blow hot air.

(d) Calculate the current drawn from the mains when the hairdryer blows hot air.

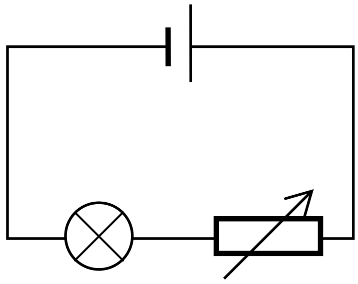
(e) Determine the minimum current drawn when the hairdryer is on.

(f) Determine the voltage across the motor.

6. Circuit Applications

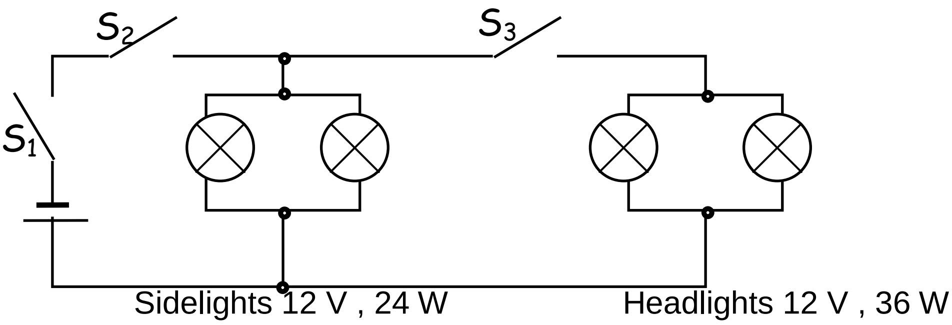
National 4

1. A circuit design for a dimmer switch is shown below:



Describe and explain what happens when the resistance of the variable resistor is increased.

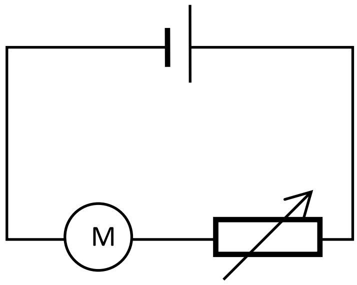
2. Here is a circuit design for toy car lights.



(a) Which switches must be closed to switch on the headlights?
(b) Which switches must be closed to switch on the sidelights only?
(c) Can the headlights be on without the sidelights?
(d) What is the advantage of having the sidelights and the headlights connected in parallel instead of in series with one another?

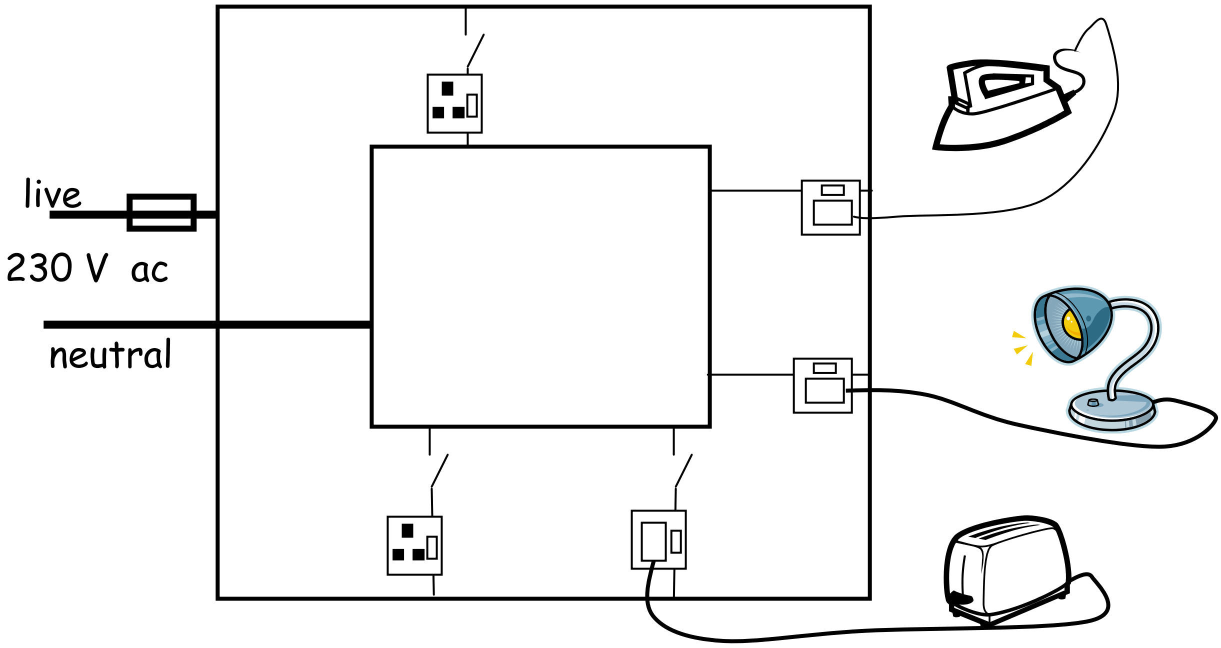
3. Give 2 examples from a typical house where 2 switches are connected in series to operate an electrical device.

4. The circuit below is used to wire up a motor inside a trick spider.



(a) When the resistance of the variable resistor is set to high, will the current be high or low?
(b) Will this make the spider move quickly or slowly?

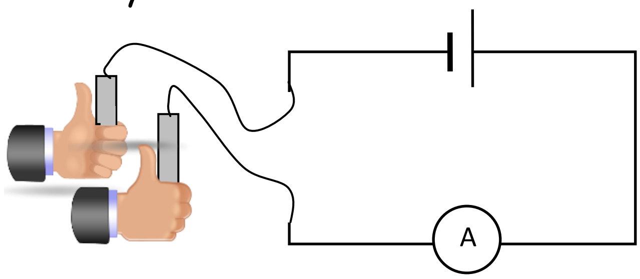
5. Sockets in a house are wired in a special parallel circuit called a "ring circuit". The diagram below shows part of this circuit.



(a) How many sockets are there in this circuit?
(b) How many appliances are plugged in?
(c) Which appliances are switched on?
(d) Which appliance is plugged in but switched off?
(e) Is the fuse in the live or neutral wire?
(f) What is the voltage of the mains supply?
(g) If all sockets are in parallel, what is the voltage across the lamp when it is on?
(h) What is the voltage across the toaster when it is on?

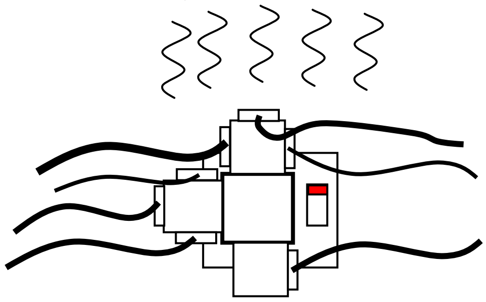
6. Wet hands have a lower resistance to electric current than dry hands. (Ask your teacher if you can test this!)

   To test this, a pupil, with **dry hands,** holds on to 2 metal bars connected to a battery and ammeter as shown:



   (a) What will happen to the resistance of the pupil's hands if he wets them?
   (b) What should happen to the ammeter reading if the pupil holds on to the metal bars with wet hands.
   (b) Why do you think it is unwise to press a switch with wet hands?

7. Why do you think it is unsafe to attach too many appliances to one socket?



8. Does household wiring connect ceiling lights in series or in parallel?

9. Find out why modern houses have circuit breakers instead of fuses.

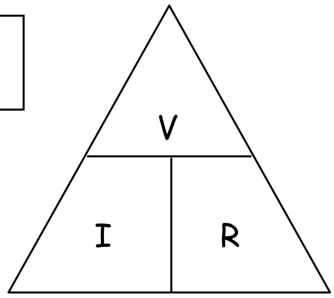
10. (Homework task!) Find out what the various circuits are in your own household wiring.
    You can do this by checking your "fuse box" which will usually have each circuit labelled.

7. Ohm's Law

National 4

In this section you can use the equation:

voltage = current x resistance



also written as:

V = IR

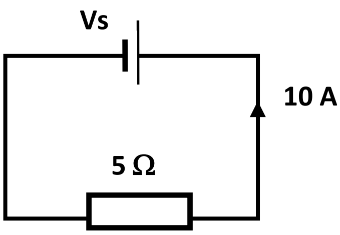
where **V** = voltage in volts (V)
I = current in amps (A)
R = resistance in ohms (Ω).

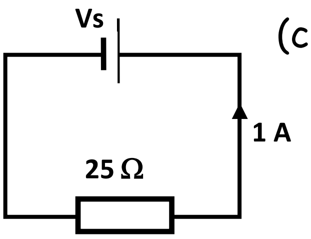
Helpful Hint.
Many appliances run from **mains** voltage which is **230 V** ac.

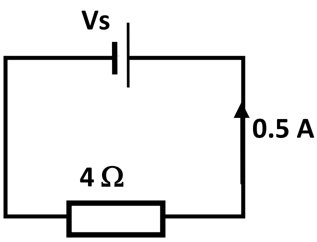
1. Copy and complete:

   voltage = c _ _ _ _ _ _ x r _ _ _ _ _ _ _ _ _ _

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

(a)


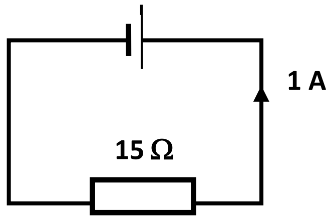
(b)


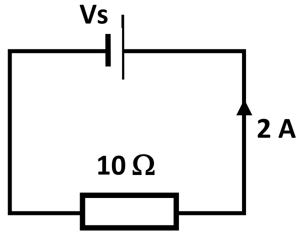
(c)


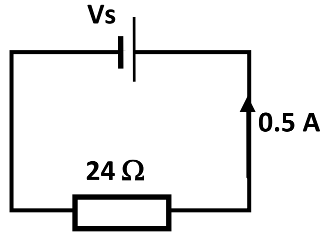
3. The maximum current an electric motor can safely handle is 0.01 A and it has a resistance of 360 Ω. Calculate its safe operating voltage.

4. A cooker draws a current of 23 A and has a resistance of 10 Ω. At what voltage should it operate?

5. Calculate the voltage across the resistor in the circuits below:

(a)


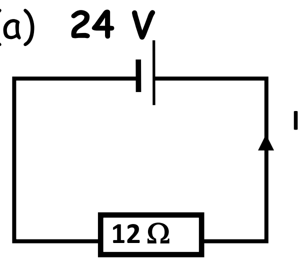
(b)


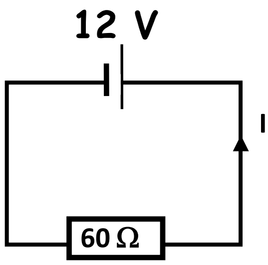
(c)


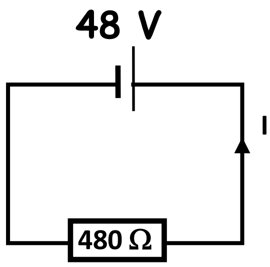
6. Copy and complete:

current = v ______ / r __________

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

(a)


(b)


(c)


8. A power drill is operated at mains voltage (230V) and has a resistance of 92 Ω. Calculate the current through the drill.

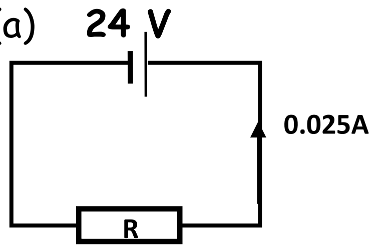
9. A 400 Ω resistor is attached to a 6 V battery. Calculate the current through the resistor.

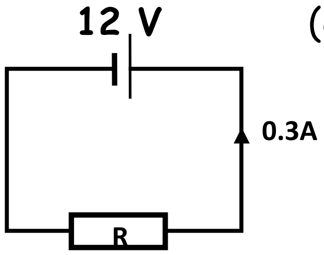
10. An energy saving bulb, which operates from the mains voltage of 230V, has a resistance of 4600 Ω.
Calculate the current through it.

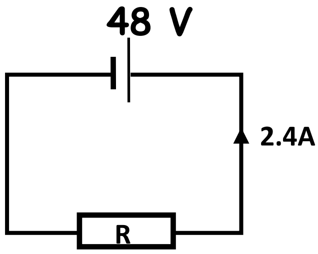
11. Copy and complete:

$$\text{resistance} = \frac{\text{v \_ \_ \_ \_ \_ \_}}{\text{c \_ \_ \_ \_ \_ \_}}$$

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

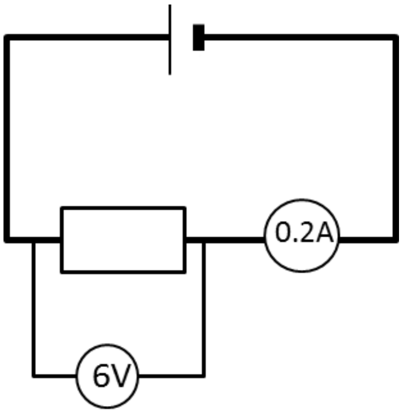
(a)


(b)


(c)


13. A hairdrier operates from the mains voltage and draws a current of 1.15 A. Calculate the resistance of the hairdrier.

14. Calculate the resistance of the resistor in the following circuit:

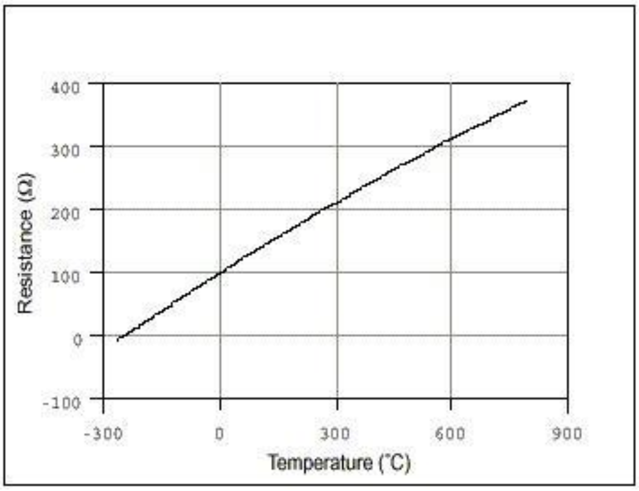


15. Calculate the resistance of a spotlight if the current through it is 0.6 A when operated by a 24 V supply.

8. Factors Affecting Resistance

National 4

1. The graph below shows how the temperature of a tungsten wire, in a bulb, affects its resistance.



(a) When we initially switch on a tungsten bulb is the wire in the bulb hot or cold?

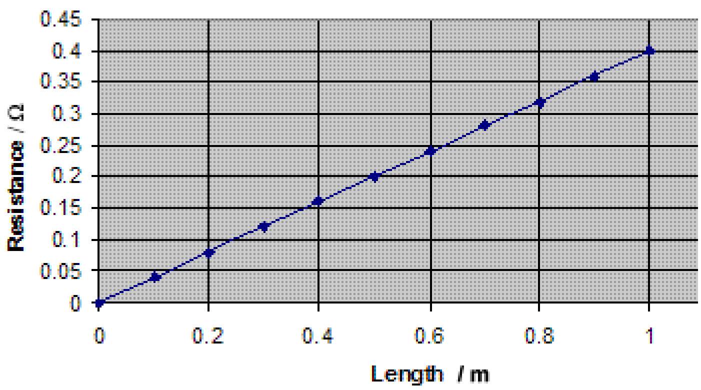
(b) Will its resistance be high or low at this point?

(c) The tungsten wire in a bulb heats up quickly after it is switched on. How will this affect its resistance?

(d) When will the current in the bulb be highest; the moment it is switch on OR after it has been on a while?

(e) Explain why bulbs usually blow at the moment they are switched on.

2. The graph below shows how the resistance of a piece of wire is affected by the length of the wire.

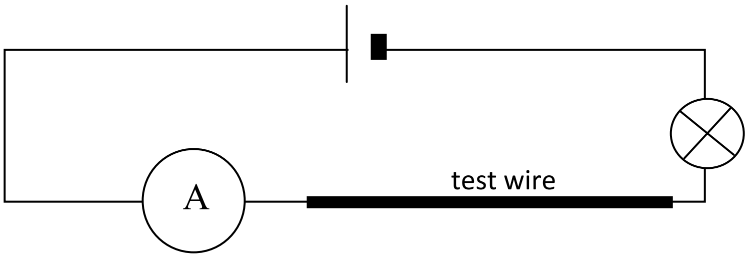


(a) Determine the resistance of a 1 m length of this wire.

(b) What length of wire gives a resistance of 0.2Ω?

(c) What conclusion can you make from these results?

3. A pupil measures the current through various pieces of wire with an ammeter. The table below shows the results.



Wire Material	**Length (cm)**	**Thick or Thin?**	**Current (A)**
steel	10	thin	0.2
steel	20	thin	0.1
steel	10	thick	0.4
aluminium	20	thin	0.5
copper	20	thin	0.8

(a) Produce a small table of results with only the readings you need to show how the **wire material** affects the current.

(b) Produce a small table of results with only the readings you need to show how the **wire length** affects the current.

(c) Produce a small table of results with only the readings you need to show how the **wire thickness** affects the current.

(d) Which material has the lowest resistance when compared with other materials of the same length and thickness?

(e) As the length of a wire is increased, does its resistance increase or decrease or stay the same?

(f) As the thickness of a wire is increased, does its resistance increase or decrease or stay the same?

9. Generation of Electricity – Energy Sources

National 3 and 4

1. Select answers to the following clues from the list below:

dynamo	**hydro electric**	**fossil fuels**
wind	**solar cells**	**solar panels**
wave power	**turbine**	**magnet**
biogas		

(a) This can be moved near a wire in order to generate electricity in the wire.

(b) This device can be turned to convert movement energy into electrical energy?

(c) Many people are having these installed on their roofs so they can make their own electricity.

(d) Some calculators don't need batteries because they have these.

(e) Coal, oil and gas are formed from animals and plants that lived millions of years ago. So what name is given to this group of fuels?

(f) This renewable fuel is made by breaking down organic matter – like sewage!

(g) In many power stations, this device spins around to turn magnets.

(h) Scotland is ideal for this type of power station as it is hilly with high rainfall.

(i) It is difficult to build this type of power station because of the stormy environment.

(k) This is a great source of movement energy to turn certain turbines.

2. Copy and complete the following table to show some advantages and disadvantages of the energy sources listed.

Electricity Generation Method	**Advantage**	**Disadvantage**
Hydro Electric Scheme		
Coal Burning Power Station		
Nuclear Power Station		
Solar Fields		
Wind Turbines		

3. (a) Explain why it is important to conserve energy.
   (b) State three ways that you can do this.

4. Make up a T-chart with 2 headings as shown below.

Renewable Energy Source	**Non Renewable Energy Source**

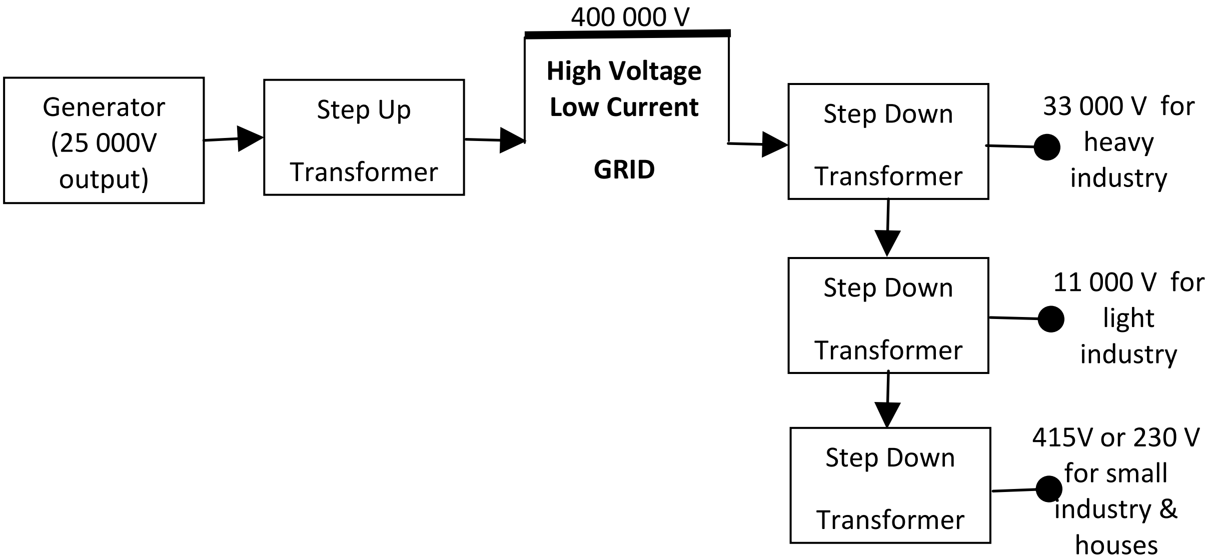
Put the following energy sources into the correct column

Coal	**Wind**	**Waves**	**Uranium**
Wood	**Sunlight**	**Oil**	**Biogas**

10. Distribution of Electricity

National 4

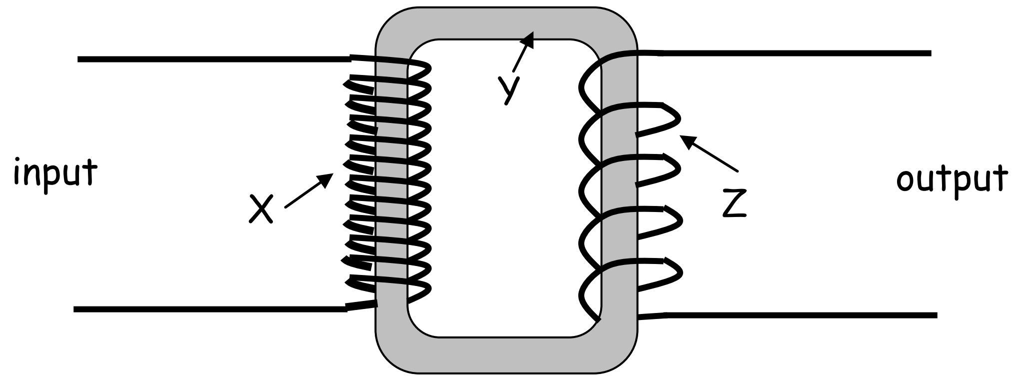
1. "The National Grid" is the network of high voltage electrical cables that carry electricity around the country.



(a) What is the output voltage from a typical generator?

(b) What device is used to change the size of an electrical voltage?

(c) A "step down transformer" is shown below:



(i) Which letter points to the "secondary coil"?

(ii) Which letter points to the "primary coil"?

(iii) Which letter points to the "iron core"?

(d) What size of voltage is used by light industry?
(e) What uses a voltage of 33 000 V?
(e) From the diagram, what does a "step up transformer" do to voltage?
(f) What does a "step up transformer" do to current?
(g) From the diagram, what does a "step down transformer" do to voltage?
(h) What do you think a "step down transformer" does to current?

2. Many people object to large pylons carrying electrical cables around the country because they say it spoils the scenery. One solution would be to bury the cables underground. Give reasons why this solution would be difficult to put in place.

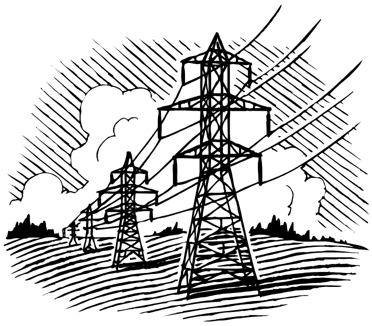
3. Why is it dangerous to fly kites near high voltage overhead cables, yet birds seem to be able to stand safely on the cables?

4. In 2009 an average citizen in Iceland used 5800 W of electrical power while a person living in Ethiopia used only 4 W. Approximately how many people from Ethiopia together consumed the same amount of energy as 1 person from the Iceland in this year?

5. **Read the following information and answer the questions that follow:**

Electrical energy is lost as electricity is transmitted through power lines as the cables heat up. The greater the distance we need to send the energy, the greater the energy loss each second. Also, the higher the current in a cable, the higher the energy loss each second.

Using a **transformer** we can increase the voltage from the power station to 400 000V for the cables in the "super grid". By using a higher voltage to transfer the electrical energy in cables we can make the current very small and so lose less energy as heat. Electricity pylons carry the electricity high above us as the high voltages used are very dangerous.



Questions

(a) When current flows through wires or cables, what type of wasteful energy is created?

(b) In order to reduce energy losses in cables, should the current flowing be low or high?

(c) In order to reduce energy losses in cables, should the voltage across the cables be low or high?

(d) What is the name of the device that can change the size of an electrical voltage?

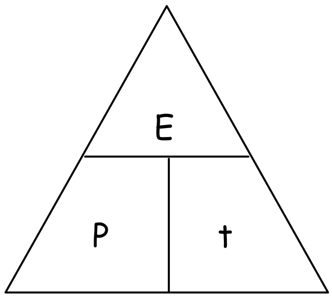
(e) What is the voltage across cables in the "super grid" ?

11. Power, Energy & Time

National 4

In this section you can use the equation:

$$\text{power} = \frac{\text{energy}}{\text{time}}$$



also written as

$$P = \frac{E}{t}$$

where **P** = power in watts (W)
E = energy in joules (J)
t = time in seconds (s).

1. Copy and complete:

   energy = p _ _ _ _ x t _ _ _

2. A 50 W immersion heater is switched on for 80 seconds. How much electrical energy passes through it in this time?

3. Calculate the energy used by a 2000 W toaster that is on for 200 s.

4. A radio has a power rating of 5 W. How much energy does it use if it is on for 1 hour (1 hour = 3600 s) ?

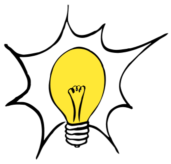
5. A 1 200 W hairdryer is switched on for 20 minutes.

   (a) How many seconds are in 20 minutes?
   (b) How much electrical energy does the hairdryer use in this time?

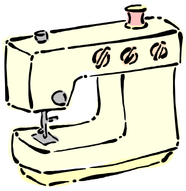
6. Copy and complete:

$$\text{power} = \frac{e\_\_\_\_\_\_}{t\_\_\_}$$

7. A bulb uses 45 000 J of energy in 300 seconds.
What is its power rating?



8.



Calculate the power rating of a toy sewing machine which uses 4 800 J of energy in 480 seconds.

9. An electric fire uses 5 220 000 J of electrical energy in 30 minutes.

(a) How many seconds are in 30 minutes?
(b) Calculate the power rating of the fire.

10. A microwave oven is on for 20 minutes each day. It uses 7 980 000 J of electrical energy in one week.

(a) For how many minutes is the microwave oven switched on in one full week?
(b) Calculate how many seconds this is equal to.
(c) Calculate its power rating?

11. Copy and complete:

$$\text{time} = \frac{e\_\_\_\_\_}{p\_\_\_\_}$$

12. A 600 W freezer used 540 000 J of electrical energy?

    (a) For how many seconds was it switched on?
    (b) Calculate this time in minutes.

13. How long will it take for a 60 W bulb to use 720 J of electrical energy?

14. How long will it take a 1 400 W paint stripper to use 1 680 000 J of electrical energy?

15. Copy and complete the following table using the appliances listed below.

appliance	**power rating (W)**
	2
	11
	250
	500
	1800
	3000

fridge/freezer   plasma TV   clock-radio
electric fire   hairdrier   energy saving bulb

12. Efficiency

National 4

In this section you can use the following two equations:

$$\text{efficiency} = \frac{\text{useful energy out}}{\text{useful energy in}}$$

$$\text{efficiency} = \frac{\text{useful power out}}{\text{useful power in}}$$

Helpful Hint

Efficiency is usually expressed as a percentage but you should change percentages to decimals before using this equation.

Example 1

A generator in a thermal power station converts 1 000 J of kinetic energy into 800 J of electrical energy.
Calculate the efficiency of the generator?

$$\text{efficiency} = \frac{\text{useful energy out}}{\text{useful energy in}} = \frac{800}{1000} = 0{\cdot}8 = \mathbf{80\%}$$

Example 2

A motor is 65 % efficient. What power can this motor deliver when it receives 2 000 W?

$$65\ \% = 0{\cdot}65 = \frac{\text{useful power out}}{2\ 000}$$

$$\text{useful power out} = 0{\cdot}65 \times 2\ 000 = \mathbf{1\ 300\ W}$$

1. Find the missing values in the following table.

	Efficiency (%)	*Useful energy in* (J)	*Useful energy out* (J)
(*a*)		1 400	700
(*b*)		675	135
(*c*)	80	1 200	
(*d*)	60	300	
(*e*)	50		1 500
(*f*)	25		6 000

2. A coal fired power station has a power output of 200 000 000 W. The input power is 250 000 000 W. Calculate the efficiency of the power station.

3. A turbine converts 65 000 J of heat energy (input) into 13 000 J of kinetic energy (output). What is the efficiency of the turbine?

4. A model generator converts 3 000 J of kinetic energy (input) into 450 J of electrical energy (output). What is the efficiency of the generator?

5. A thermal power station converts 420 000 000 J of chemical (input) energy into 126 000 000 J of electrical (output) energy. What is the efficiency of this power station?

6. An electrical pump used in a pumped storage hydroelectric power station is 80 % efficient (0.8 as a decimal). How much output energy can it produce if it is supplied with 25 000 J of input energy each second?

7. An oil fired power station which is 40% efficient produces an output of 300 000 000 W. How much power must be supplied to the station to produce this output?

8. The output from an oil-fired power station is 250 000 000 W and it is 40 % efficient. How much power must be provided by the oil to produce this output?

9. The Glenlee hydroelectric power station produces an output of 24 000 000 W. How much put in by water falling from the reservoir if the station is 25 % efficient?

10. The boiler of a thermal power station releases 2 800 000 000 J of heat energy for each kilogram of coal burned (input energy). The generator of the power station produces 1 260 000 000 J of electrical energy for each kilogram of coal burned (output energy). What is the efficiency of this power station?

11. The tidal power station at the Rance in France has 24 turbines. Each one can generate an output of 10 000 000 W from the tidal currents funnelled into the river estuary. If each turbine is 50 % efficient, calculate the input power at one turbine.

12. The input energy carried by water flowing into the turbines of a hydroelectric power station is 4 500 000 J. How much electrical energy could this power station give out if it is 35 % efficient?

13. A house has solar panels to provide domestic hot water. The input to the solar panels is 1800 W on a summer day and the panels are 20% efficient. Calculate the output power that would be produced by the panels on such a day.

14. The average power in waves washing the north Atlantic coast of Europe is 50 kW per metre of wave front.
   (a) How much input power would be required from the waves to generate an output of 10 000 kW using a 50 % efficient wave - power machine?
   (b) How many metres of wave front would this require?

15. The 3 MW wind turbine at Burger Hill in Orkney provides energy for the national grid. This turbine is 25 % efficient.

   (a) What % of the 3 MW is wasted in this system.
   (b) How much power is wasted?

13. Electromagnetism

National 4

1. Magnetic fields exist around magnets and their effect can be shown by scattering iron filings around a magnet. The filings "line up", to follow the magnetic field pattern, in lines. We say the direction of a magnetic field points from the NORTH pole to the SOUTH pole.

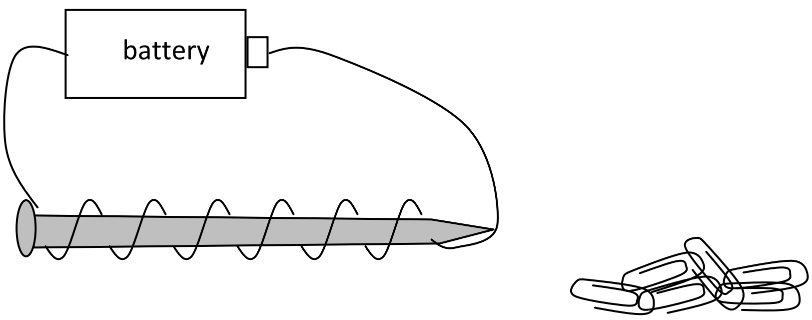
   (a) Copy the diagrams below and add lines with arrows to show the magnetic fields.

   (i) [S N] [S N]

   (ii) [S N] [N S]

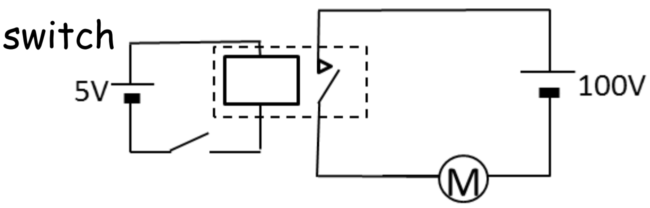
   (b) Beside each diagram in part (a), state whether the magnets will attract or repel each other.

2. An electromagnet can be made easily by coiling a wire around an iron nail as shown below. One way of testing the strength of the electromagnet is to find out how many paper clips it can pick up.



   (a) State one advantage of an electromagnet over a permanent magnet.
   (b) State two ways to make the magnet stronger.
   (c) State two uses of electromagnets.

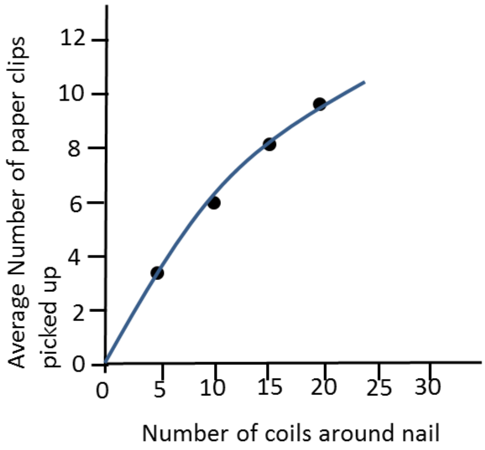
3. A "relay switch" can be used to switch on high voltage circuits using a low voltage supply.



(a) Describe how the relay works.

(b) Why do you think it is safer to switch on the motor with a relay switch?

4. The graph below shows how the number of paper clips picked up by an electromagnet is affected by the number of times it is coiled around the iron nail.

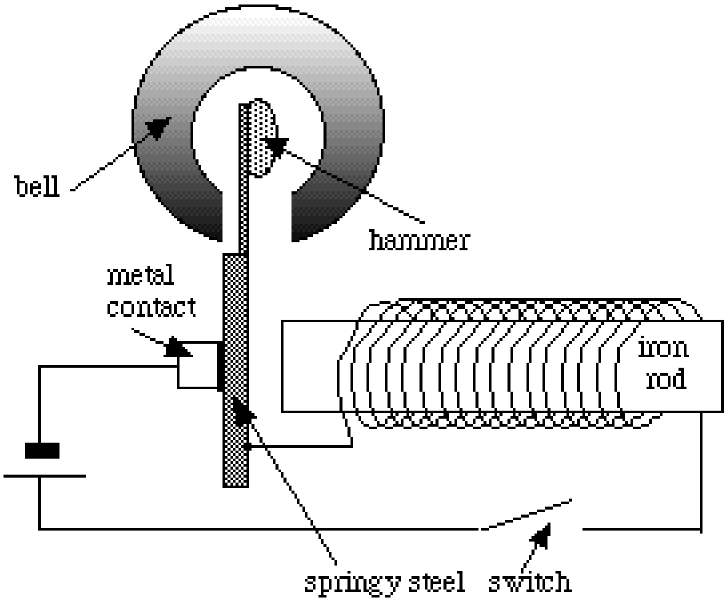


(a) Use the graph to determine the average number of paper clips that were picked up when 10 coils were wrapped around the nail.

(b) Suggest how many coils should be wrapped around the nail in order to pick up 5 paper clips.

(c) Predict how many paper clips would be picked up when 30 coils are wrapped around the nail.

5. A basic design for an electric bell is shown below.



Explain how the bell operates.

14. Heat

National 3 & 4

1. What is the unit for "heat"?

2. What is the unit for "temperature"?

3. Select the correct word, "**heat**" or "**temperature**", to complete each of the following sentences:

   (a) _________________ is a measure of how hot or cold something is.

   (b) _________________ is an energy that can flow from one object to another by conduction, convection or radiation.

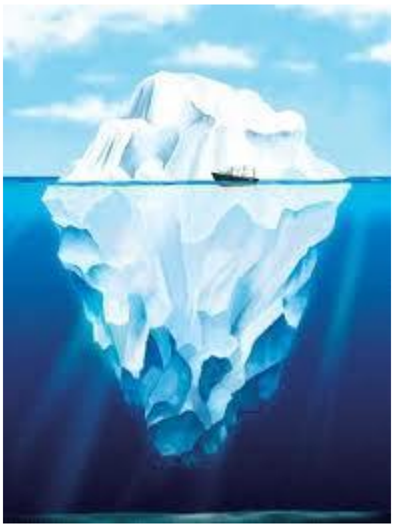
   (c) _________________ is a measure of the total movement energy of atoms in the object.

   (d) _________________ is a measure of the average movement energy in each atom.

4. Compare these 2 objects:

<u>A hot cup of tea at 70 °C</u>

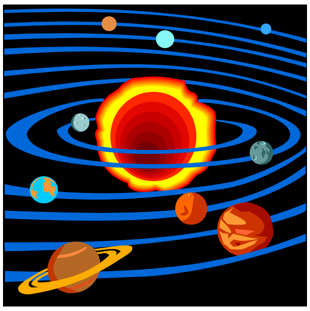
<u>An iceberg at – 20 °C</u>



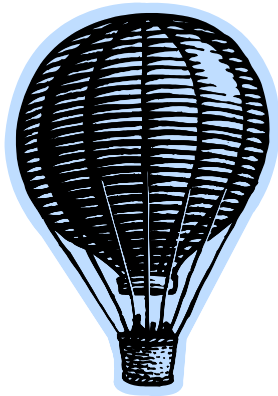
   (a) Which is hotter?
   (b) Which has more heat energy?
   (c) Explain your answer to part (b).

5. Look at each of the following pictures and decide if heat is mainly moving by **conduction**, **convection** or **radiation**.

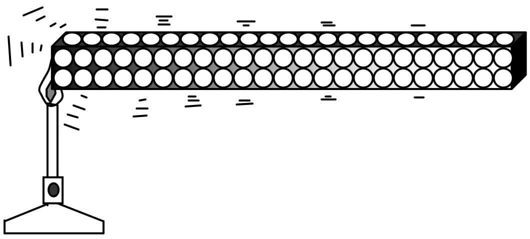
(a)



(b)



(c)



6. Select the correct word, "**conduction**", "**convection**" or "**radiation**", to complete each of the following sentences:

(a) ____________________ happens when warmer liquids and gases rise because they are less dense.

(b) ____________________ is when heat is transferred as infrared waves.

(c) ____________________ is the transfer of heat energy through solids as particles vibrate faster.

(d) ____________________ is the only way that heat can pass through a vacuum.

(e) Heat travels through the oceans by __________________ .

(f) Heat travels through Space by __________________ .

(g) Heat travels through a pot by _____________________ .

15. Gases

National 4

1. Select the correct word, "**pressure**", "**volume**" or "**temperature**", to complete each of the following sentences:

   (a) The amount of space a gas takes up is its ____________ .

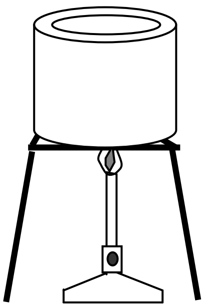
   (b) We measure ______________ in **Pascals**.

   (c) We measure _______________ in **degrees Celsius**.

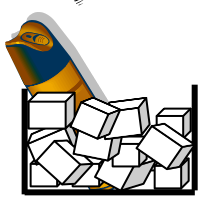
   (d) The force of gas particles hitting off an area of their container tells us the _______________ of the gas.

   (e) We measure ________________ in **cubic metres**.

2. Will the gas pressure inside the following objects **increase**, **decrease** or **stay the same**:

   (a)  sealed canister of air being heated

   (b)  air filled balloon being squeezed.

   (c)  aerosol can put in ice

3. Explain why the pressure in car tyres increases as more air is pumped in.

4. Explain why car tyres are marked with a maximum pressure limit.

5. The air pressure decreases, the higher we go from the surface of Earth.

   (a) Explain why aircraft cabins must contain pressurised air.
   (b) Predict and explain what might happen if an explosion happened on an aeroplane at 40 000 feet, blowing open a door.

6. The summit of Mount Everest is at 8848 m. At this height the air pressure is approximately one third of the air pressure at sea level. In addition, the temperature at the summit of Everest averages around – 19°C in summer, dropping to -36°C in winter.

   (a) Use your knowledge of temperature and pressure to explain why you think it is very difficult to survive for very long at this altitude.

   (b) Research what the main health risks are for high altitude climbers, due to the drop in air pressure.

7. Read the information below and overleaf and use it to answer the questions that follow:

The Dangers of Scuba Diving

As scuba diving is a popular recreational sport, beautiful coral reefs and eerie shipwrecks around the world have become major tourist draws in their own right. However, it should not be forgotten that scuba diving is an extreme sport with its own peculiar injuries and potentially life-threatening hazards. Most of these scuba diving dangers stem from the effects of the increased water pressure of the undersea environment, but there are also dangers posed by sea life and faulty equipment.

Barotrauma

Barotrauma is caused by the damage done by increased underwater pressure on the air pocket in the middle ear. Divers usually "equalize" during a dive by pinching their nose shut and blowing, by chewing or by swallowing to push more air into the middle air. However, a descent that is too fast can result in severe pain and even injury to the middle ear.

Decompression Sickness

Often called "the bends," decompression sickness is caused by increased underwater pressure causing the body's tissues to absorb more nitrogen. If that pressure is suddenly reduced, this extra nitrogen forms potentially harmful bubbles. Deep divers return to the surface in carefully monitored stages so as to control the rate at which this absorbed nitrogen is released. A case of the bends can range from aching joints or a skin rash to paralysis and death.

Nitrogen Narcosis

Another nitrogen-related danger is the narcotic effect of all that extra nitrogen in the body. Nitrogen narcosis is a danger because it impairs judgement and sensory perception. As with the bends, the degree of nitrogen narcosis is related to how deep a diver goes and how much nitrogen they absorb.

Oxygen Toxicity

Oxygen toxicity is usually a problem only encountered by deep divers who go below 135 feet. The body absorbs extra oxygen under increased underwater pressure. For most divers this is not a problem, but at extreme depths so much extra oxygen is absorbed that this life-giving gas becomes a poison. The effects range from tunnel vision and/or nausea to twitching to loss of consciousness and/or seizures.

Pulmonary Embolism

Another risk facing a diver who rapidly ascends to the surface is pulmonary embolism. The increased pressure of the undersea environment results in extra gas being crammed into the same lung space. A rapid rise to the surface can cause the lungs to swell and even pop like a balloon because the water pressure decreases. Scuba divers guard against pulmonary embolism by making slow, controlled ascents to the surface and by never holding their breath.

Sea Life

Divers should never forget that each dive is the equivalent of entering an untamed wilderness. While most sea creatures are not aggressive towards divers and attacks are extremely rare, incidents do happen and a diver cannot afford to forget that she is surrounded by wild animals. The famed TV wildlife host "Crocodile Hunter" Steve Irwin was killed in 2006 when he was stung through the chest by a stingray, a frequently encountered and usually harmless sea creature. Divers should always treat sea life with great care and respect.

Defective Equipment

Many casual scuba divers do not own their own equipment, and are therefore reliant on renting equipment from the scuba diving operator who is conducting their dive trip. A broken depth gauge could lead to a mild case of decompression sickness, while a bad regulator might result in drowning. A diver should always thoroughly check rented scuba diving equipment, and never be shy about asking for a new piece of gear if they suspect something is wrong with what they have.

Questions

(a) Which part of the body can be damaged by "barotrauma"?

(b) How can a diver prevent or reduce the effect of barotrauma?

(c) What is the scientific term for "The Bends"?

(d) "The Bends" is caused by the body absorbing which gas?

(e) What other condition can be caused by the body absorbing too much of the gas in Q. 4?

(f) In high pressure environments, like deep sea, the body can absorb too much oxygen. What are the effects of this?

(g) If a diver gets into difficulty underwater, should the diver swim to the surface as quickly as possible? Explain your answer.

(h) Apart from the dangers due to the change in water pressure, name two other hazards that might face a diver.