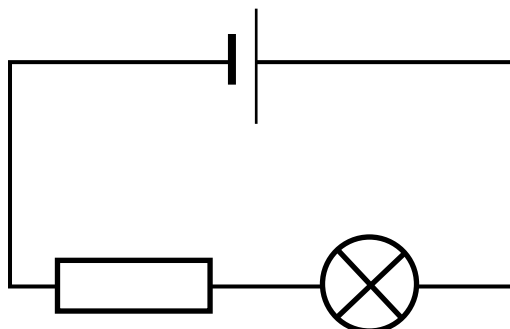


Electrical charge carriers and electric fields

Electric charge

1. What moves through a conductor when a current flows through it?
2. Using correct symbols, redraw the circuit below showing how an ammeter would be positioned to measure the current flowing through the lamp.



Charge, current and time

3. State an equation that links charge, current and time.
4. Calculate the missing values in the table below.

<i>Charge</i>	<i>Current</i>	<i>Time</i>
(a)	2 A	20 s
(b)	100 mA	10 s
300 C	0.1 A	(c)
1040 C	13 A	(d)
3.0 C	(e)	60 s
9 C	(f)	3 minutes

5. Calculate the total charge which flows through a lamp drawing 100 mA for 200 s.
6. A current of 0.5 A flows through a circuit in a time of 10 s.
 - (a) Calculate the total charge flowing through the circuit.
 - (b) If a single electron carries a charge of 1.6×10^{-19} C, how many electrons flowed through the circuit?
7. Calculate the current flowing if 30 C of charge flows through a component in 10 s.

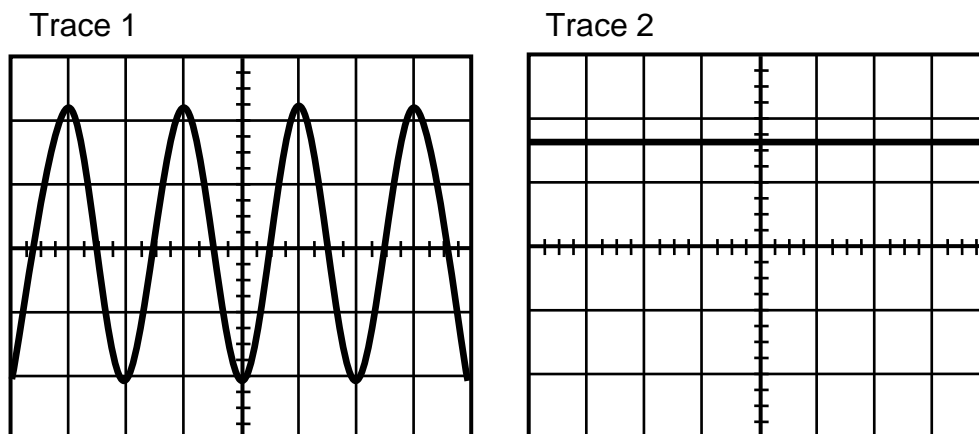
8. What time will it take for 500 C of charge to pass through a circuit if the current in the circuit is 500 mA?

a.c. and d.c.

9. State a source of an a.c. supply and a d.c. supply.

10. What frequency is the mains supply in Scotland?

11. State which of the oscilloscope traces below shows a d.c. and which an a.c. supply.



Potential difference (voltage)

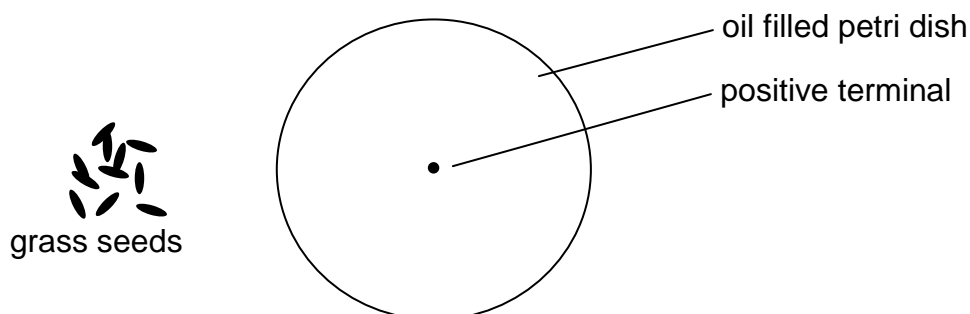
12. Copy and complete the paragraph on potential difference and electric fields using the words given below.

energy negative voltage positive negative
attracted potential charge positive

An object can have either negative or positive charge. Electrons have _____ charge, When a charged object is placed in an electric field, its movement will depend upon its _____. A positive charge will be repelled by a _____ charge whilst a negative charge will be _____.

In a circuit, it is electrons which flow around the circuit. The energy for them to move comes from a _____ difference or _____. Electrons will flow towards the _____ connection of a power supply and away from the _____ connection. The size of the potential difference or voltage is a measure of the _____ given to the electrons.

- 13.** Electric fields are invisible. They can be shown by sprinkling grass seeds or semolina onto an oil filled petri dish to which an electric field is applied.



Draw the field that would be seen when the grass seeds are dropped onto the oil.

- 14.** A Van De Graaff is charged up and the dome becomes positively charged. Describe what would be seen if:

- A.** a small negatively charged object was thrown at the dome and
- B.** a small positively charged object was thrown at the dome.

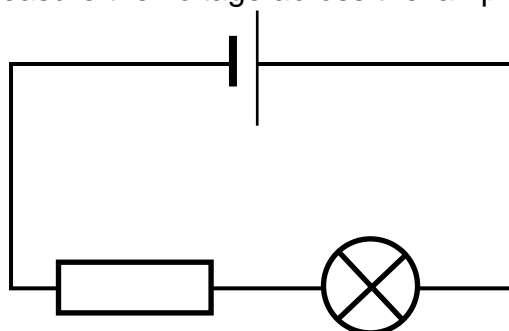


- 15.** A pupil stands on an insulated platform and touches the dome of a Van de Graaff generator. His hair is observed to 'stand on end'.

- (a) Explain this effect in terms of charges.
- (b) Why must he stand on an insulated platform?

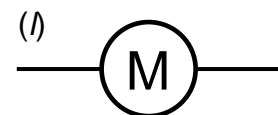
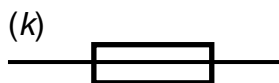
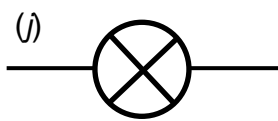
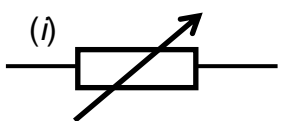
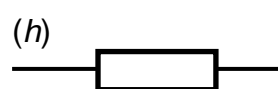
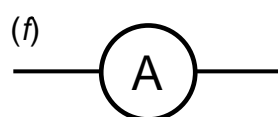
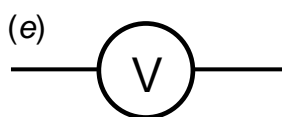
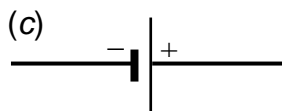
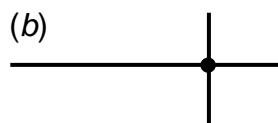


- 16.** Using correct symbols, redraw the circuit below showing how a voltmeter would be positioned to measure the voltage across the lamp.

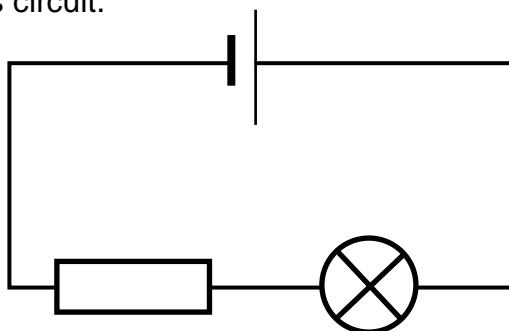


Ammeters, Voltmeters and circuits

17. Identify the symbols of the electrical components shown below.



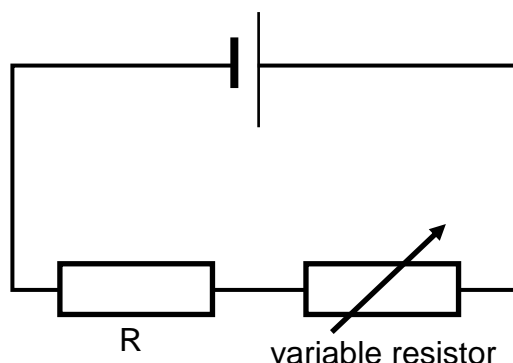
18. (a) A circuit is shown below. State the components that would be required to wire up this circuit.



(b) Redraw the circuit with a voltmeter and ammeter correctly positioned to measure the voltage across the lamp and the current through the lamp.

Ohm's Law

19. A pupil sets up a circuit to investigate how the voltage across a resistor affect the current through it. A variable resistor is used to change the current flowing through the resistor, R . The partially completed circuit is shown below.



- (a) Copy the circuit above and add a voltmeter to measure the voltage across resistor, R , and the current through it.
- (b) What will happen to the current flowing through R if the resistance of the circuit is increased by increasing the resistance of the variable resistor?
- (c) The resistor is replaced by a length of wire. This is dipped into liquid nitrogen at a very low temperature.
 - (i) What effect will this have on the resistance of the wire?
 - (ii) State what will happen to the current flowing in the circuit as a result.

20. A class is asked to investigate the relationship between voltage and current for a conductor with fixed resistance. A circuit similar to that in question 19 is set up and pupils gather their results together. All the experiments used wire of the same length. Their averaged results are shown below.

<i>Voltage in volts, V</i>	2	4	6	8	10	12
<i>Current in amps, I</i>	0.25	0.5	0.75	1.0	1.25	1.5
<i>V/I</i>						

- (a) Why is it a good idea for the class to combine all their results and find average values?
- (b) Why must wire of the same length be used for each experiment.
- (c) The pupils calculate a value for voltage divided by current.
 - (i) Copy the table above and complete the row headed V/I
 - (ii) What conclusion can be drawn from the results?

21. A pupil sets out to investigate the resistance of a conductor. The following apparatus is collected:

voltmeter;
ammeter;
variable voltage power supply;
resistor;
connecting leads.

(a) Draw a circuit diagram showing how the components can be connected to carry out the investigation.

(b) The results from the experiment are shown below.

<i>Voltage in volts, V</i>	1	2	3	4	5	6
<i>Current in milliamps, I</i>	51	105	148	200	250	298

Plot a graph of these results and use the graph to determine the resistance of the resistor used in the experiment.

22. State an equation that links voltage, current and resistance.

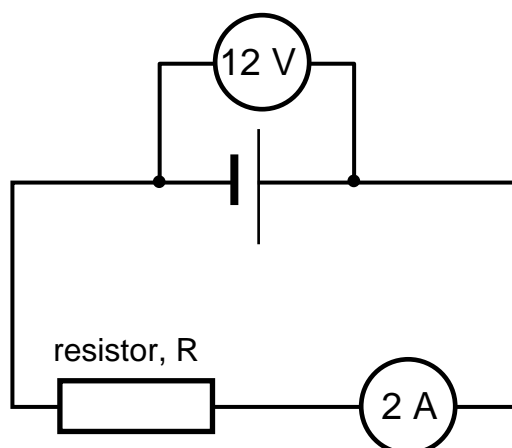
23. Calculate the missing values in the table below.

<i>Voltage</i>	<i>Current</i>	<i>Resistance</i>
(a)	0.5 A	20 Ω
(b)	4 A	15 Ω
230 V	8 A	(c)
12 V	0.02 A	(d)
230 V	(e)	500 Ω
12 V	(f)	60 Ω

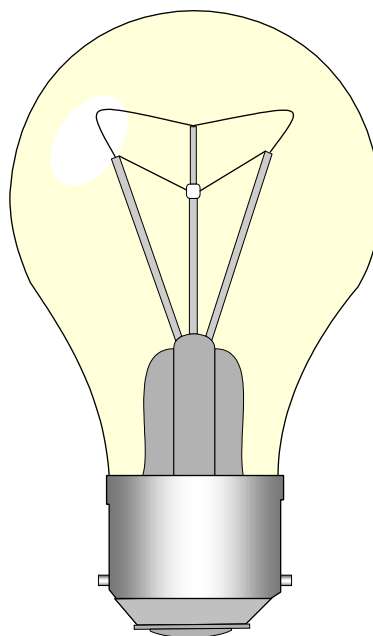
24. A circuit is constructed using a power supply with a variable voltage output. It is connected to a fixed value of resistance. What will happen to the current in the circuit as the voltage is increased?

25. An electric kettle is connected to mains electricity at 230 V. A current of 5 A flows to the kettle when it is switched on. Calculate the resistance of the kettle element.

26. A $36\ \Omega$ resistor is connected to a $1.5\ \text{V}$ supply. Calculate the current passing through the resistor.
27. An electric iron has a resistance of $76\ \Omega$. Calculate the voltage across it when the current to the iron is $3.0\ \text{A}$.
28. A resistor with a value of $2200\ \Omega$ is connected to an electronic circuit. Calculate the current through it when a voltage of $2.2\ \text{V}$ is applied across it.
29. Calculate the value of the resistor, R , in the circuit below.

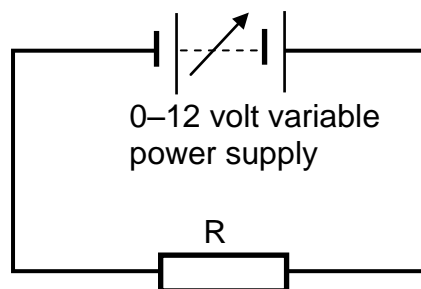


30. A filament type electric light bulb has a resistance of $980\ \Omega$ when operating at normal brightness.
- (a) Calculate the current through the light bulb when it is connected to a $230\ \text{V}$ mains supply.
- (b) Before it was switched on, the light bulb had a resistance of only $64\ \Omega$.
- (i) Suggest a reason for this difference in resistance.
- (ii) Calculate the current through the light bulb when it is first switched on.
- (c) Light bulbs most often fail when switched on from cold. Can you suggest a reason why this should happen.

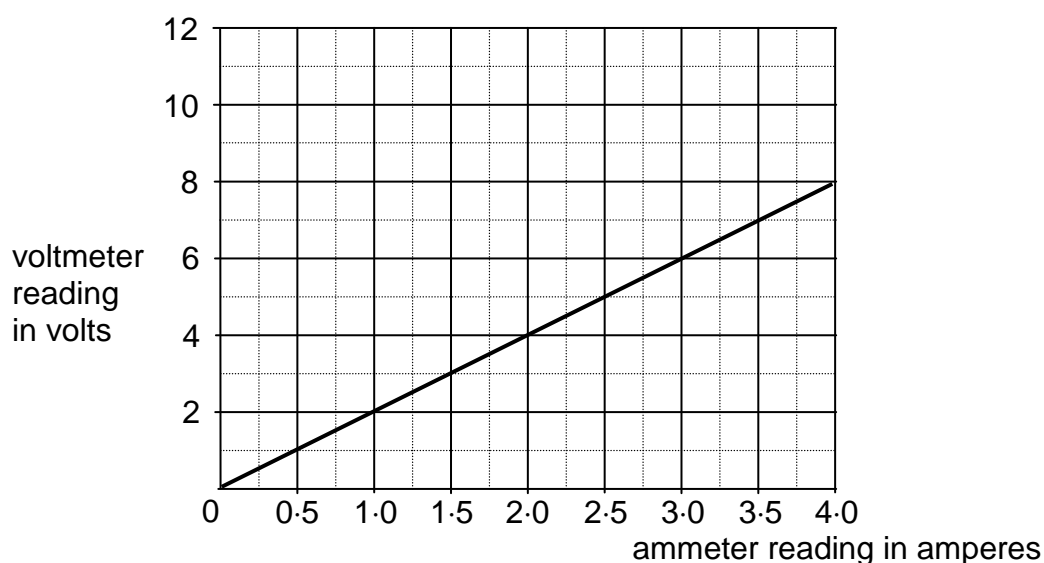


Extension Questions

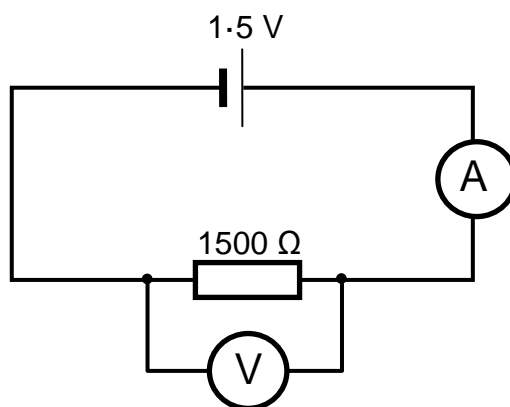
31. A pupil sets up the circuit shown opposite. An ammeter and voltmeter are to be added to the circuit to make measurements so that the resistance of the resistor can be calculated.



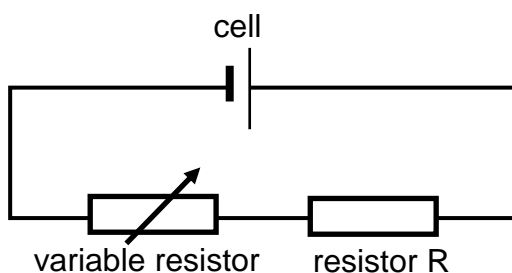
- (a) Redraw the circuit with the ammeter and voltmeter correctly positioned to make the readings.
- (b) Readings are taken from the ammeter and voltmeter as the power supply voltage is altered and a graph produced from the measurements.



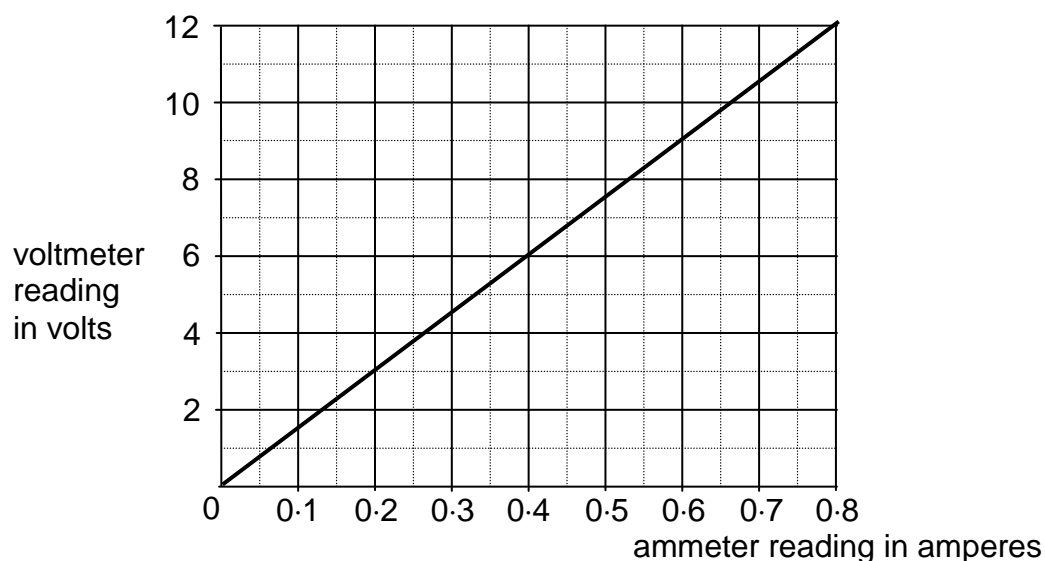
- (i) What is the reading on the ammeter when the voltage across the resistor is 4 volts?
- (ii) Taking readings from the graph, calculate the resistance of the resistor in the circuit.
32. Find by calculation, the readings that would be on the voltmeter and ammeter in the circuit below.



33. A pupil investigates the relationship between current and resistance in a circuit containing a resistor as shown below. A variable resistor in series with the resistor R, is used to change the current flowing in the circuit.



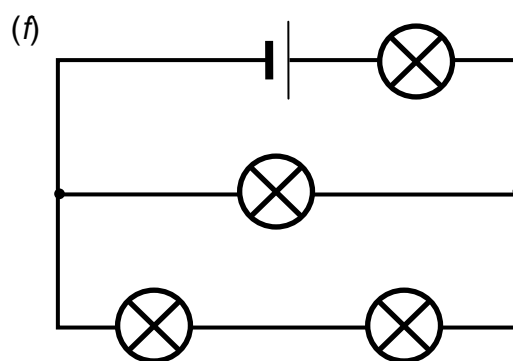
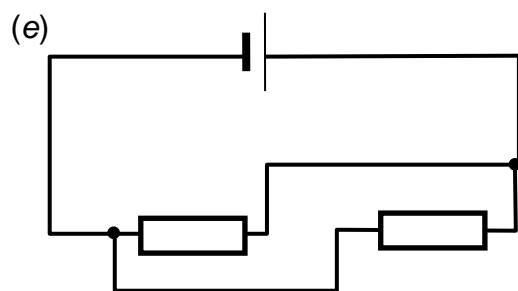
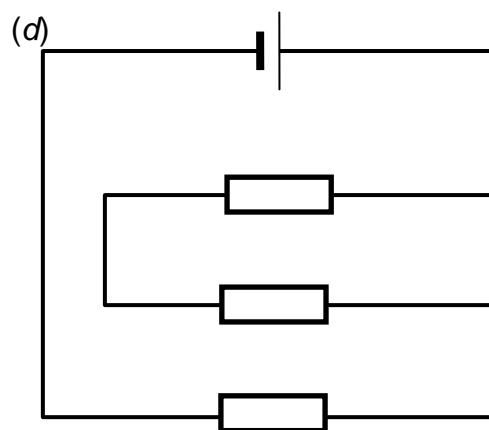
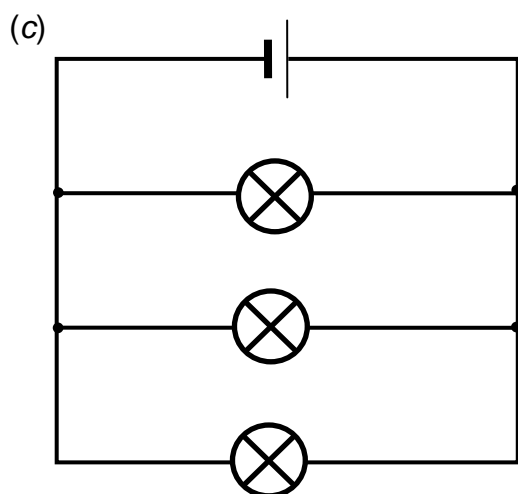
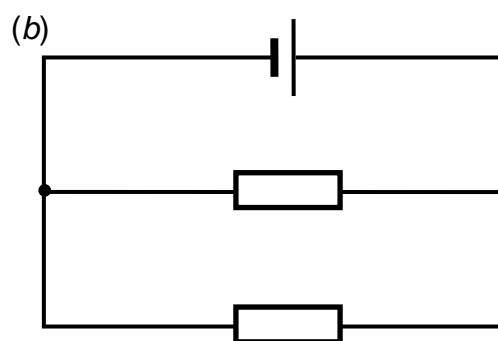
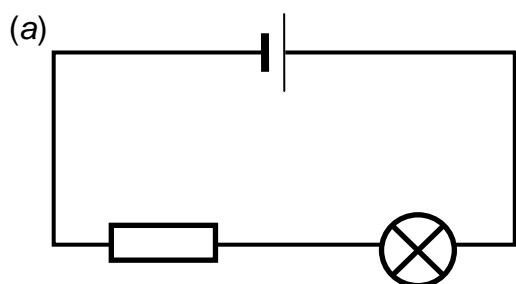
- What can be said about the value of the current flowing through the variable resistor and resistor R?
- Redraw the circuit and show, using the correct symbols, a correctly placed ammeter to measure the current through R and a correctly placed voltmeter to measure the voltage across R.
- A graph is produced from the results obtained from the experiment. Use these results to calculate the resistance of resistor R.



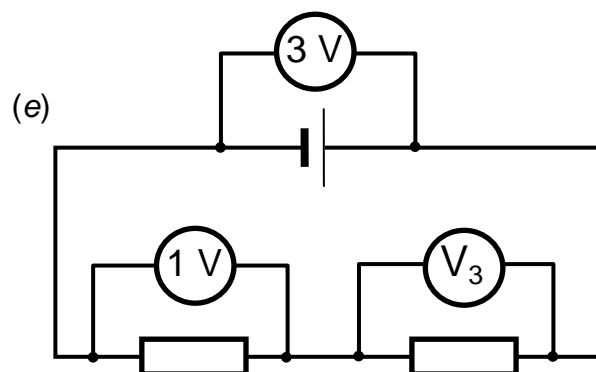
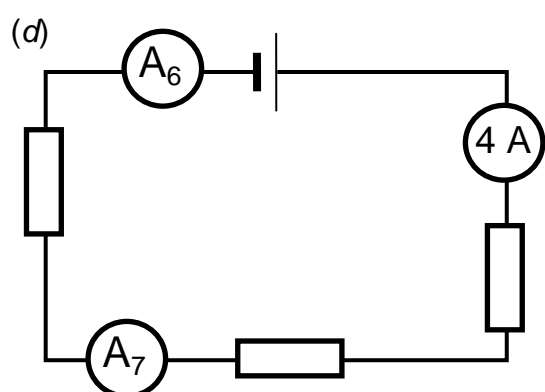
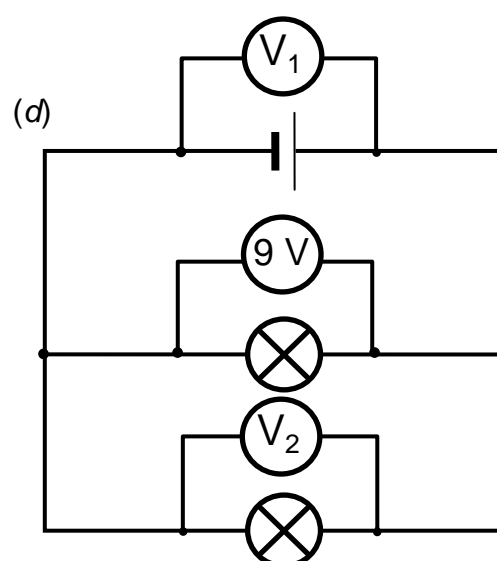
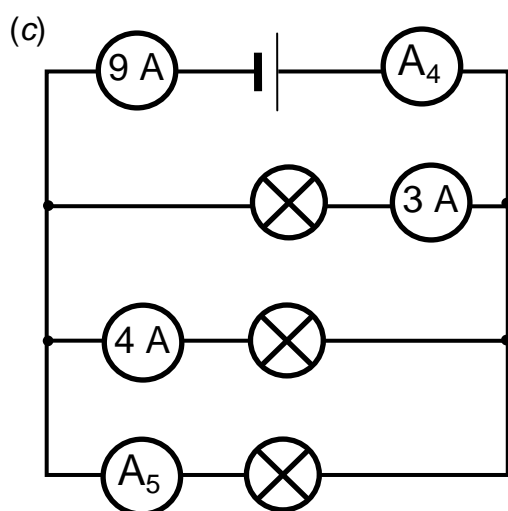
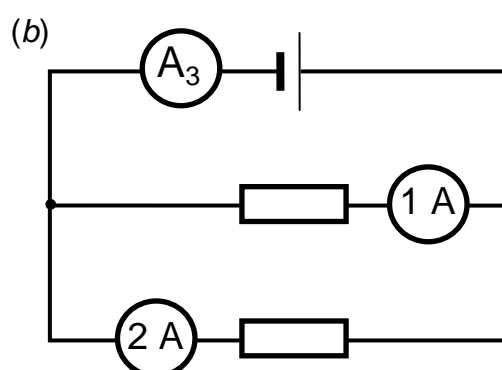
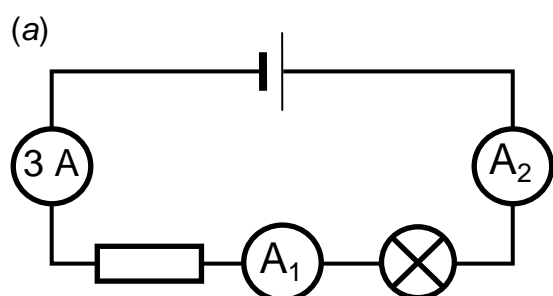
- The value of the variable resistor is now **increased**. What effect will this change have on the reading on the ammeter?

Series and parallel circuits

34. State which of the following circuits are series circuits and which are parallel circuits.



- 35.** Look at the circuits below. Use your knowledge of how current and voltage behave in series and parallel circuits to find the readings on the ammeters and voltmeters.

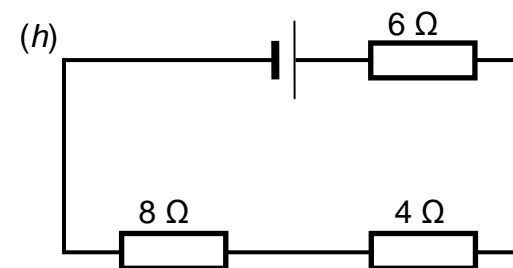
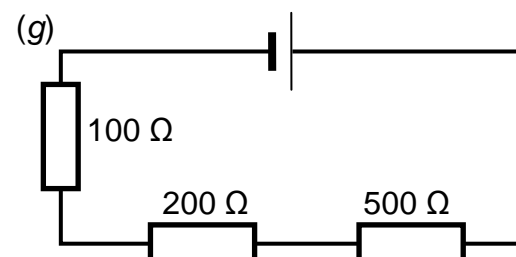
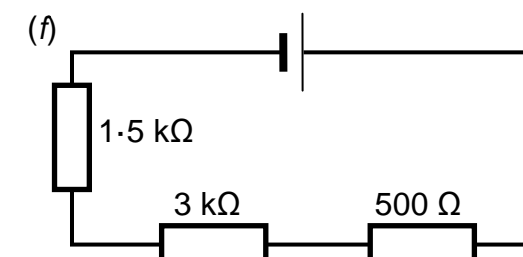
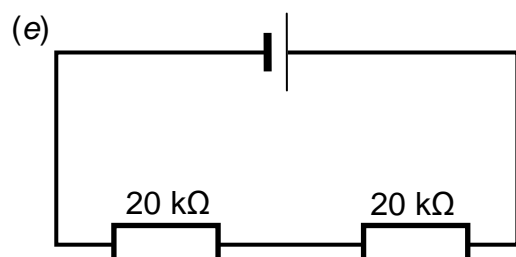
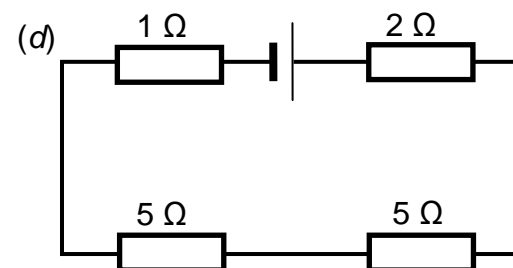
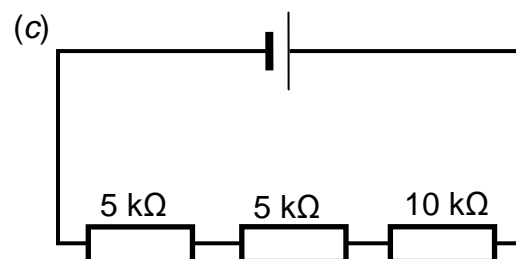
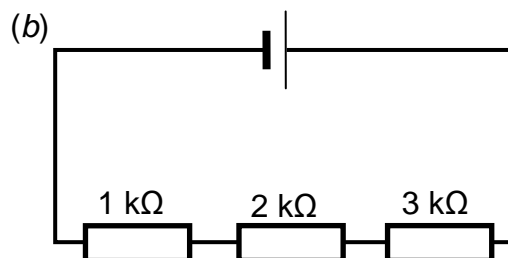
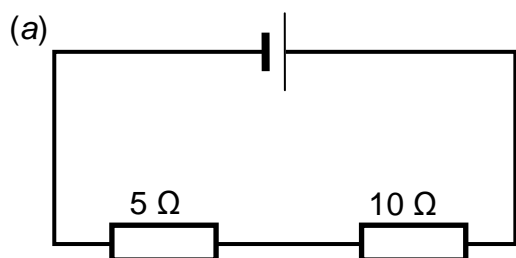


Resistors in series and parallel

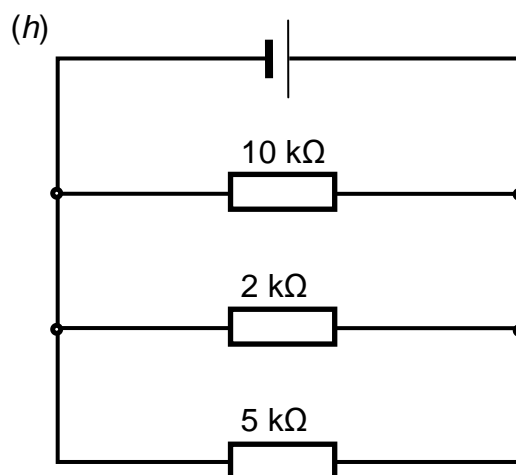
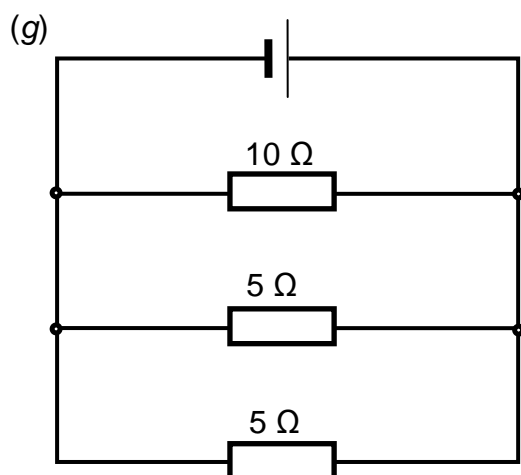
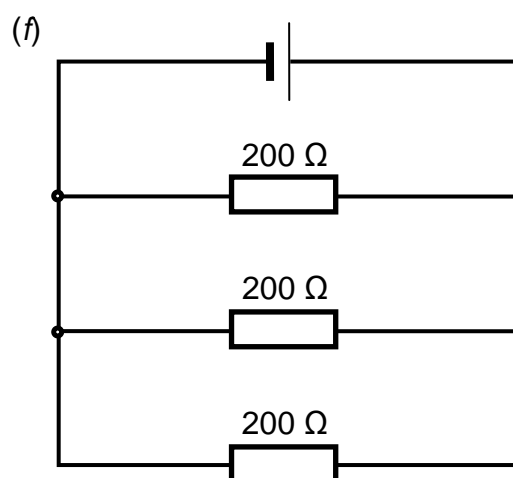
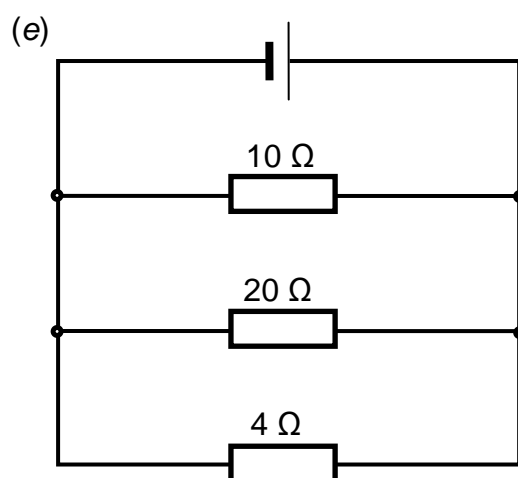
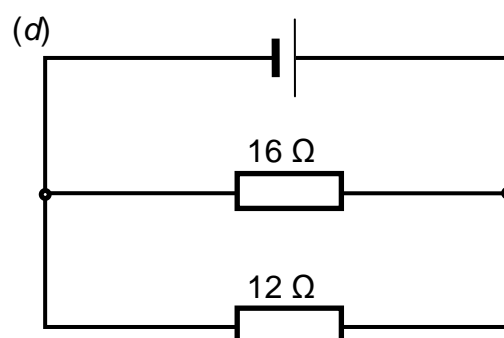
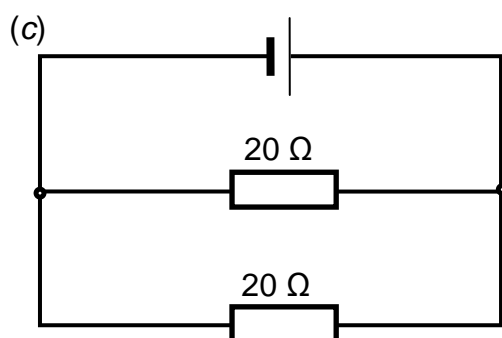
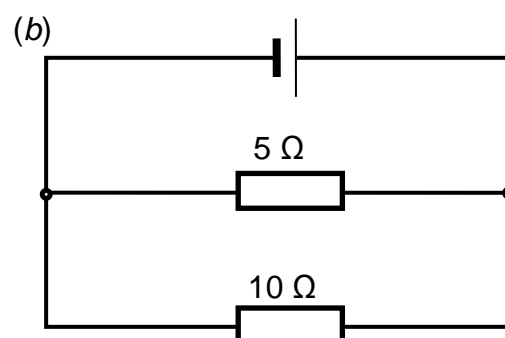
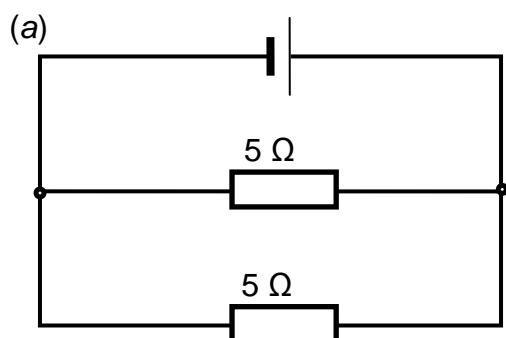
36. Write down a formula that can be used to find the total resistance of three resistors connected in series.

37. Write down a formula that can be used to find the total resistance of three resistors connected in parallel.

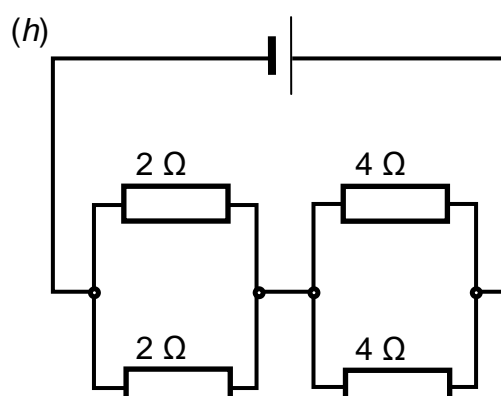
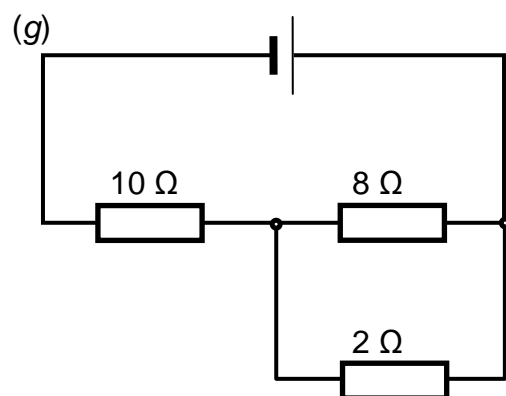
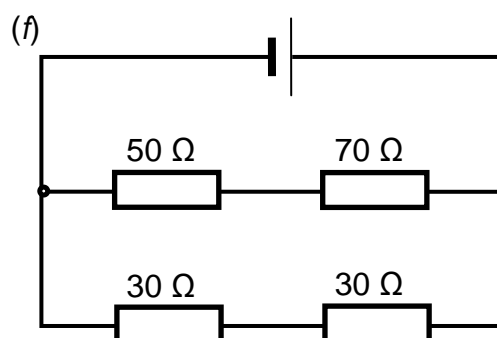
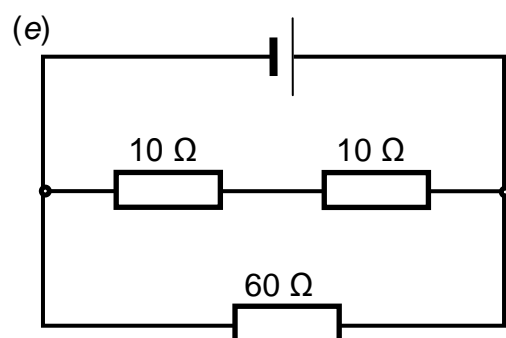
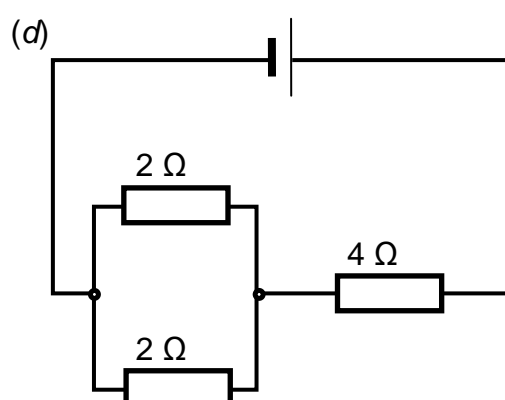
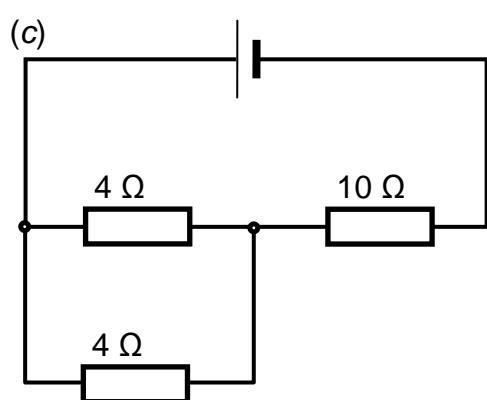
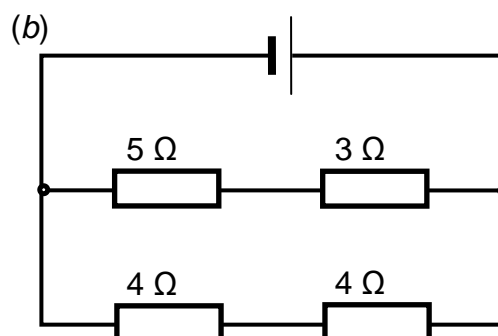
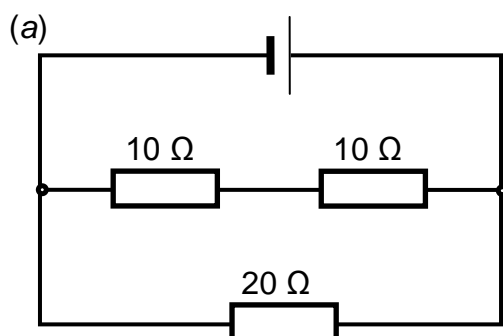
38. The circuit diagrams below show resistors connected in series. Calculate the total resistance of the circuits.



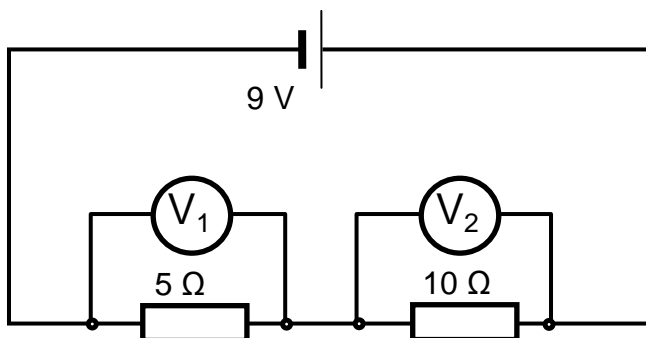
39. The circuit diagrams below show resistors connected in parallel. Calculate the total resistance of the circuits.



40. The circuit diagrams below show resistors connected in a mixture of series and parallel. Calculate the total resistance of the circuits.

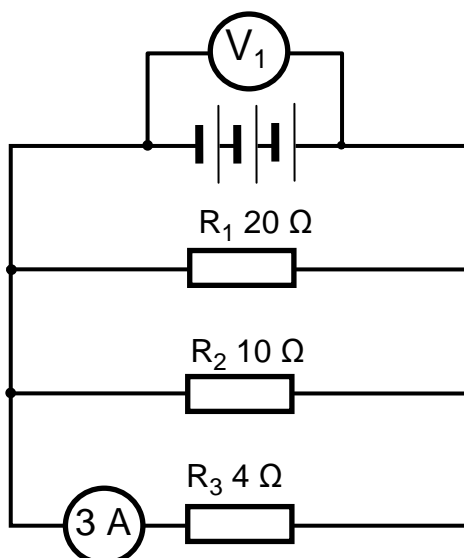


41. A circuit consists of two resistors connected in series.



- Calculate the total resistance of the circuit.
- A 9 V cell is used as the power source. Calculate the current in the circuit
- Calculate the readings on:
 - Voltmeter V_1 ;
 - Voltmeter V_2 .

42. A pupil connects three resistors as shown in the circuit opposite.

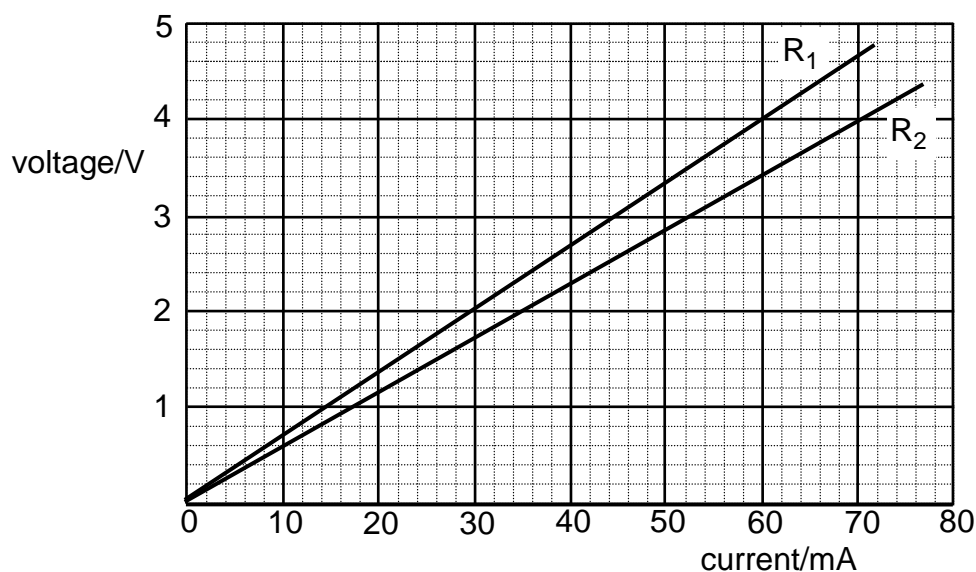


- Calculate the total resistance of the circuit.
- The current through the $4\ \Omega$ resistor is 3 A. Calculate the voltage across R_3 .
- State the voltage across R_1 and R_2 .
- State the reading on meter V_1 .
- Calculate the current through:
 - Resistor R_1 ;
 - Resistor R_2 .

Extension Questions

43. An electronics company supplies resistors in packets of ten. The resistors should be within 5% of their stated value.

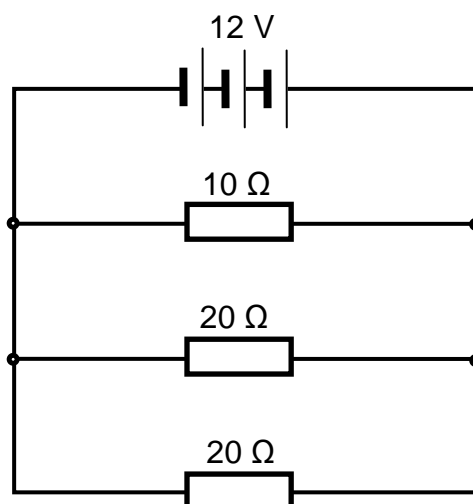
- (a) (i) The stated value of the resistors is $60\ \Omega$. Calculate 5% of $60\ \Omega$.
 (ii) What is the allowed range of values for the resistors.
- (b) A pupil takes two of the resistors and, after connecting them to a power supply, measures the current through the resistors at various values of voltage. The graph obtained is shown below.



- (i) Use the graphs to find the value of R_1 and R_2 .
 (ii) State if the resistors fall within the allowable range.
- (c) Three $60\ \Omega$ resistors are connected in parallel. Calculate their total resistance.
- (d) A pupil needs a $150\ \Omega$ resistor to complete an electronics project but only has $60\ \Omega$ resistors available.

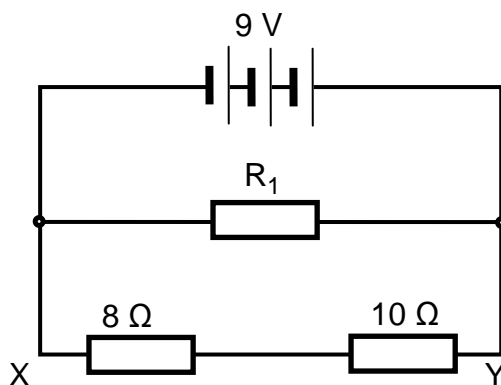
Show how a number of $60\ \Omega$ resistors could be connected together to provide the correct resistance.

44. A pupil connects three resistors in parallel as shown below.



- (a) (i) Calculate the total resistance of the circuit.
- (ii) Calculate the current leaving the power supply.
- (iii) One of the resistors develops a fault and no longer conducts. State and explain the effect this will have on the current leaving the power supply.
- (b) Another pupil suggests placing a voltmeter across each of the resistors in turn to find which is faulty. Comment on the effectiveness of this suggestion.

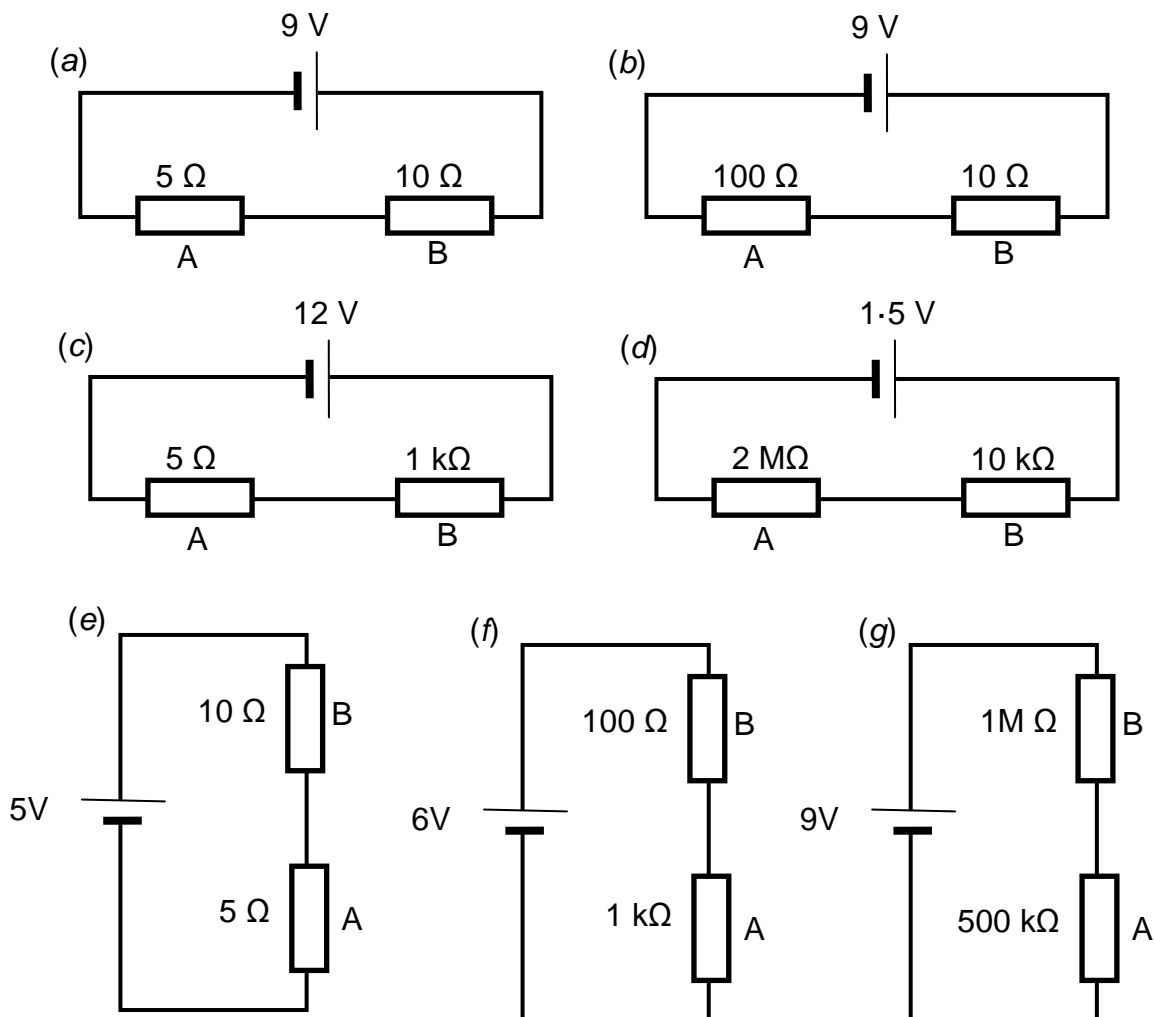
45. Examine the circuit shown below.



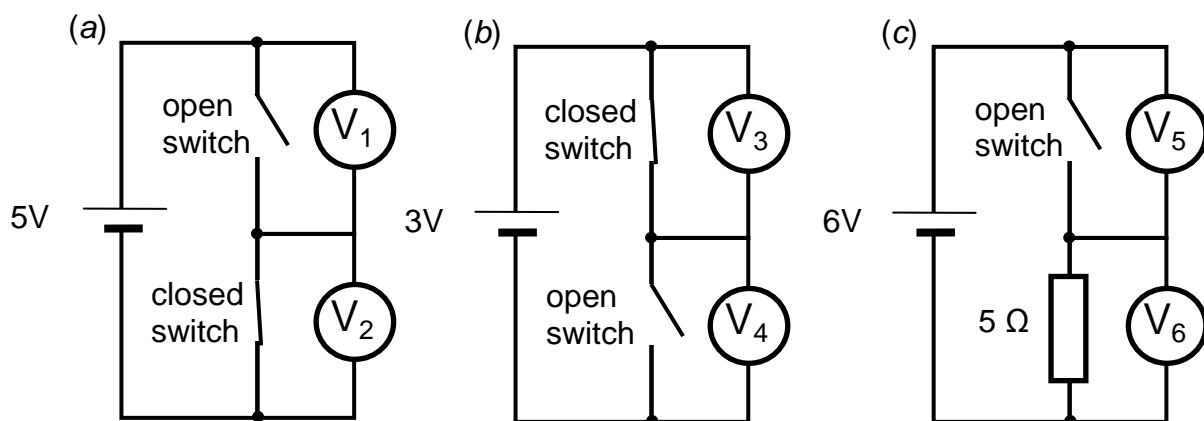
- (a) State the voltage between points X and Y.
- (b) The voltage across the $8\ \Omega$ resistor is 4 V. Calculate the voltage across the $10\ \Omega$ resistor.
- (c) Calculate the total resistance between points X and Y.
- (d) Calculate the current flowing between X and Y in the circuit.
- (e) The current through R_1 is 1.5 A. Calculate the resistance of R_1 .

- 46.** If two resistors are in series across a supply the voltage will be divided between them. The higher the resistance the larger the share of voltage across that resistance.

State which resistor in the circuit diagrams below will have the larger voltage across it.

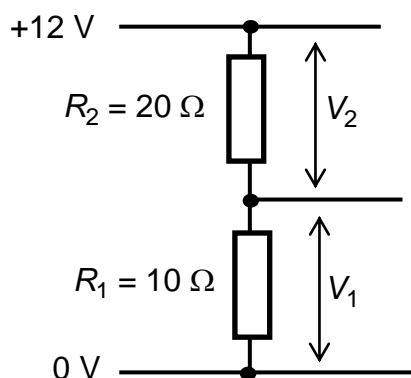


- 47.** A switch which is open will have infinite resistance, a closed switch will have zero resistance. Use this information to state the voltages across the switches in the following circuits.



48. Read the passage below on voltage dividers.

Potential or voltage dividers are used to divide a voltage. It may use a mixture of resistors, variable resistors and devices such as thermistors or light dependent resistors. The voltage across any single resistor depends upon what proportion its resistance is of the total resistance of the circuit. Suppose we want to find the voltage across the two resistors in the circuit shown below.



The 12 V supply voltage will divide in proportion between the 10 Ω and 20 Ω resistors. The voltage across each resistor can be calculated as follows.

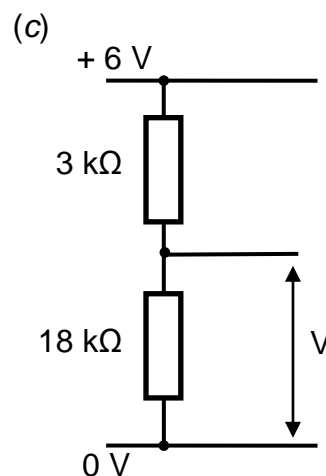
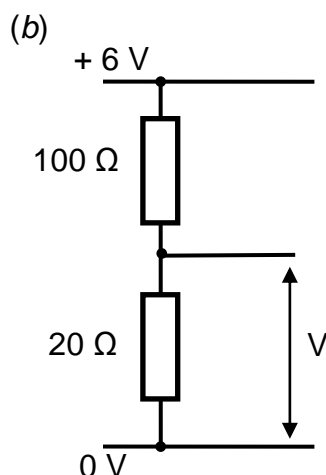
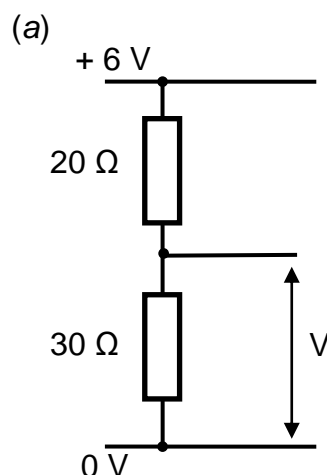
Total resistance of circuit = $20\ \Omega + 10\ \Omega = 30\ \Omega$.

$$\text{so, } V_1 = \frac{10}{30} \times 12 \quad \text{and} \quad V_2 = \frac{20}{30} \times 12$$

$$= 4\ \text{V} \quad \quad \quad = 8\ \text{V}$$

This can be put into a general formula $V_1 = \left(\frac{R_1}{R_1 + R_2} \right) \times V_{\text{supply}}$

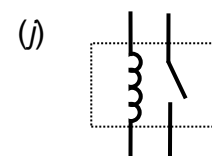
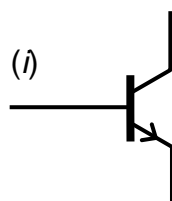
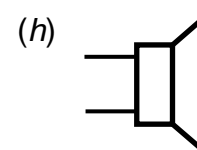
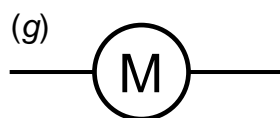
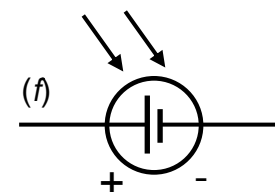
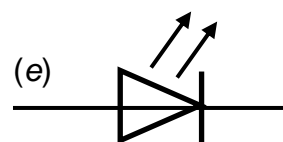
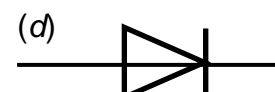
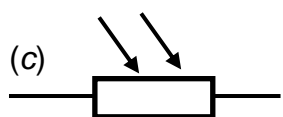
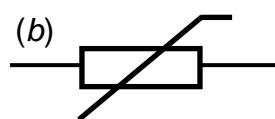
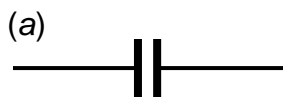
Use the above information to calculate the voltage, V, in each of the following voltage dividers.



Electronic circuits

49. Match the symbols of the following electrical components with the symbols shown below.

diode loudspeaker thermistor
light dependent resistor photovoltaic cell transistor
motor relay LED capacitor



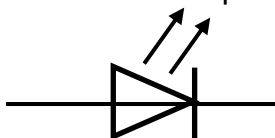
50. Some of the devices in question 49 are input devices and some are output devices. Copy and tick the appropriate box to show which is which. The first is done for you.

Device	Input device	Output device
(a) loudspeaker		✓
(b) capacitor		
(c) LED		
(d) LDR		
(e) thermistor		
(f) relay		

51. The table below lists a number of electronic devices. Copy and complete the table to show the energy input and the energy output.

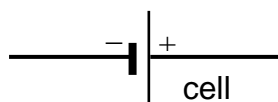
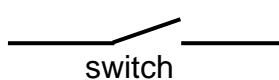
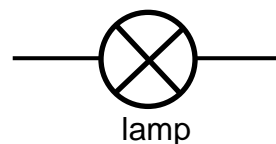
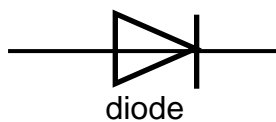
<i>Device</i>	<i>Input energy</i>	<i>Output energy</i>
(a) loudspeaker		
(b) LED		
(c) LDR		
(d) thermistor		
(e) relay		
(f) motor		
(g) photovoltaic cell		

52. The circuit symbol for a light emitting diode is shown below. Copy the symbol and indicate which connection must be positive and which negative for the LED to light.

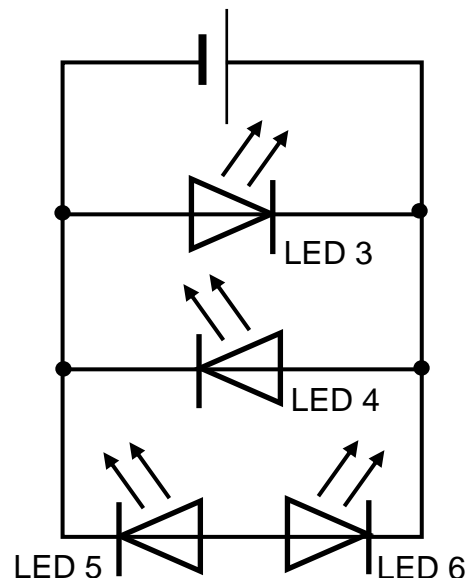
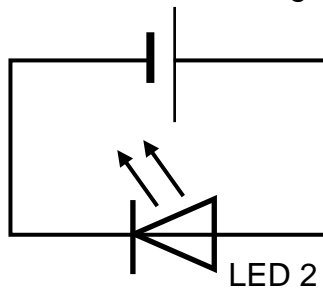
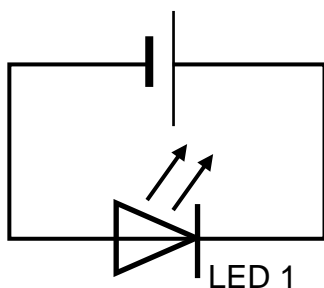


53. The list of components shown below are available to a pupil. Use these to construct a circuit diagram which will allow the lamp to light. All the components must be used.

connecting wire



54. State which of the LEDs in the circuits below will light.



55. Draw the symbol for a capacitor and state its function.

56. A capacitor is connected to a 12 V power supply in series with a resistor.

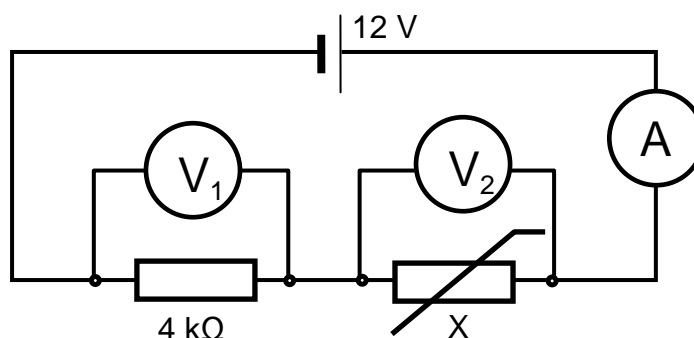
- (a) What will be the voltage across the capacitor when it is:
- (i) fully charged;
 - (ii) uncharged.
- (b) The resistor is replaced with one with a larger resistance. State the effect this has on:
- (i) the time it takes to charge;
 - (ii) the final charge stored on the capacitor;
 - (iii) the final voltage across the capacitor.

57. Copy and complete the paragraph on electronic components using the words given below.

resistance temperature decreases increases does not change

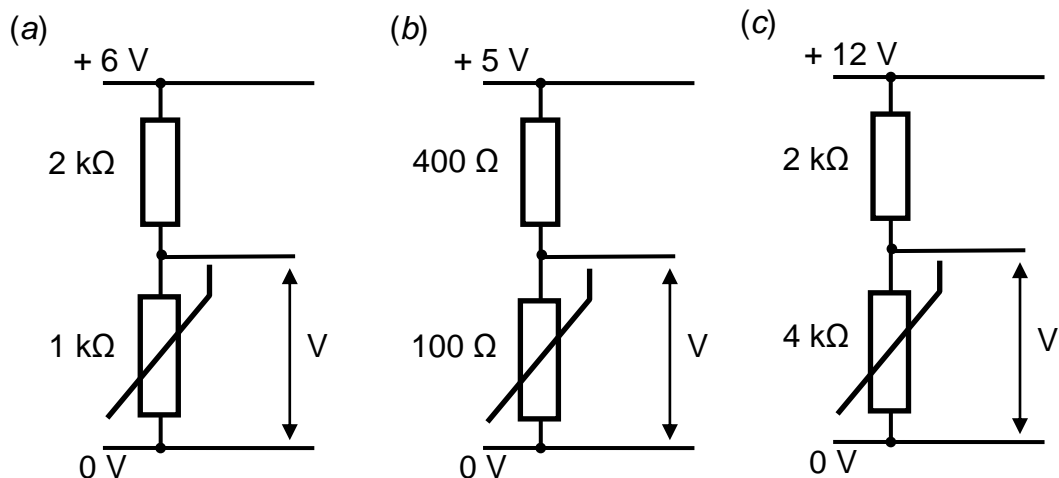
A resistor will normally have a resistance which _____. The resistance of some devices will change according to certain factors. The resistance of a thermistor changes with _____. For most thermistors, as the temperature increases its resistance _____. LDRs change their _____ with changing levels of light. As the light levels decrease, the resistance of the LDR _____.

58. Look at the circuit diagram opposite.

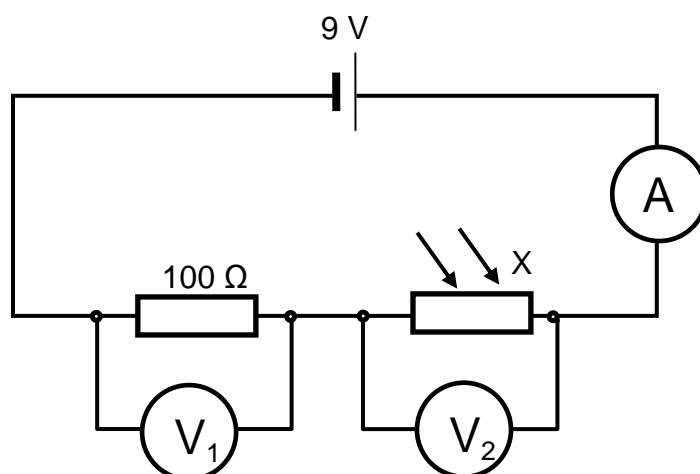


- (a) Name component X.
- (b) The ammeter indicates a current of 2 mA. Calculate the voltage reading on the voltmeter V₁.
- (c) Calculate the voltage reading on V₂.
- (d) Calculate the resistance of component X.
- (e) State what will happen to the reading on the ammeter if:
- (i) the temperature of the 4 kΩ resistor rises;
 - (ii) the temperature of component X rises

59. Each of the circuits below contain a resistor and thermistor. Calculate the voltage across the thermistor in each one.

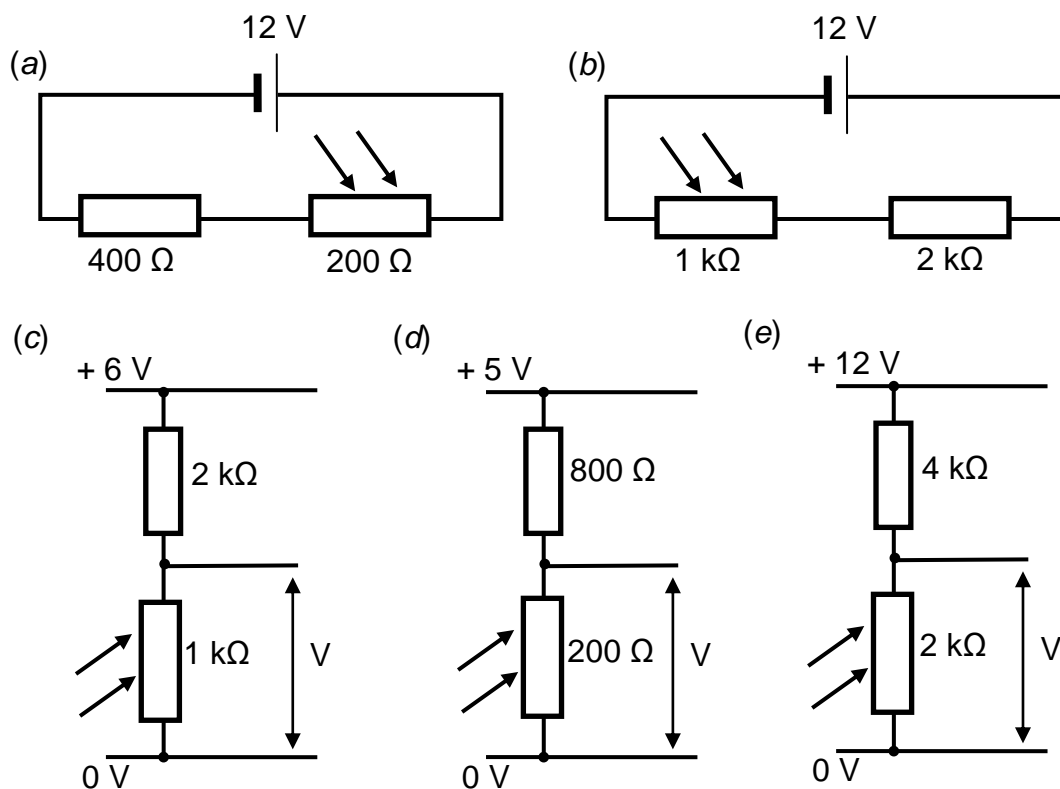


60. Look at the circuit diagram below.

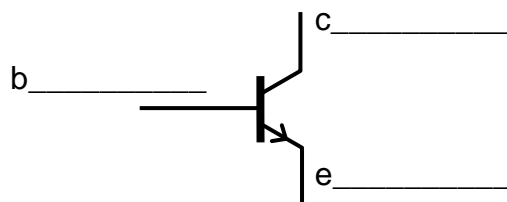


- Name component X.
- The ammeter indicates a current of 30 mA . Calculate the voltage reading on the voltmeter V_1 .
- Calculate the voltage reading on V_2 .
- Calculate the resistance of component X.
- State what will happen to the reading on the ammeter if the light level falling on component X increases.

61. Each of the circuits below contain a resistor and a light dependent resistor (LDR). Calculate the voltage across the LDR in each one.



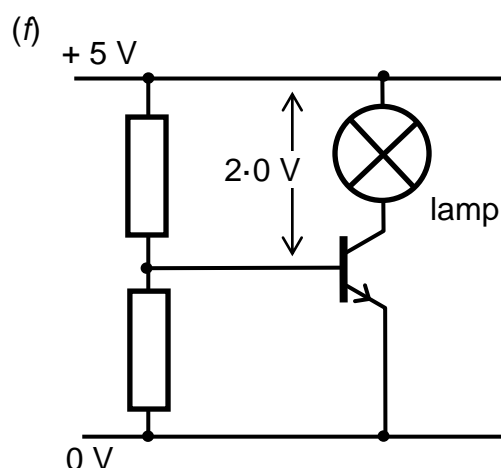
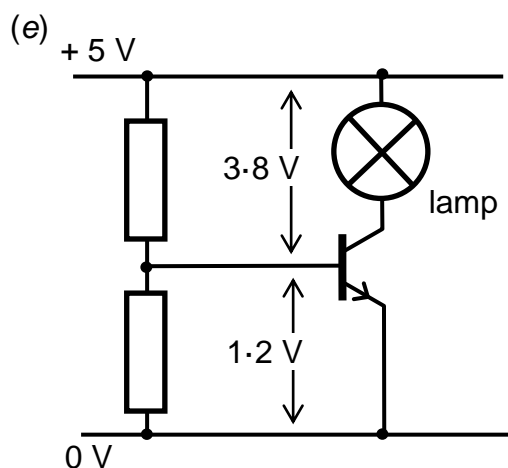
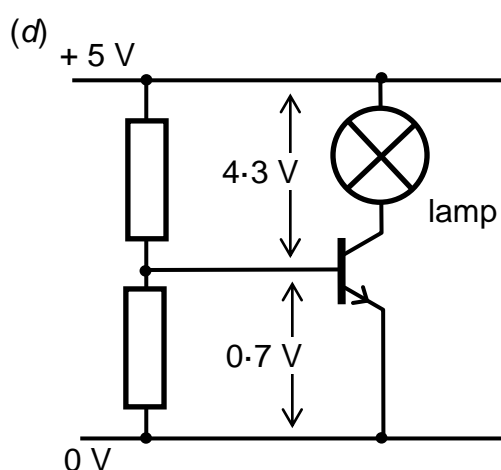
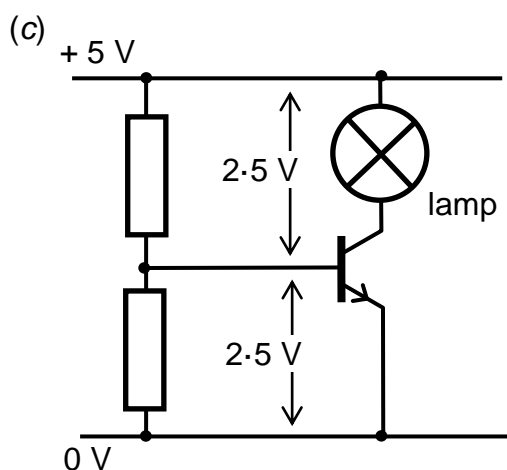
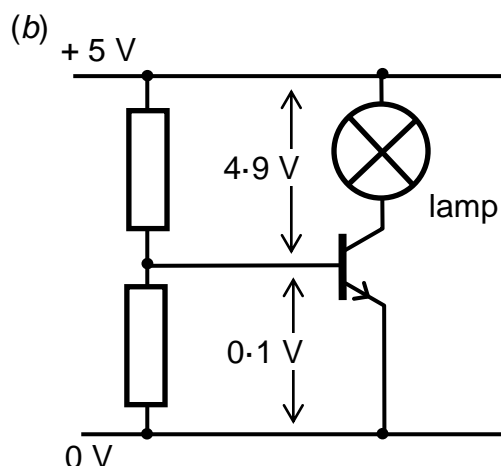
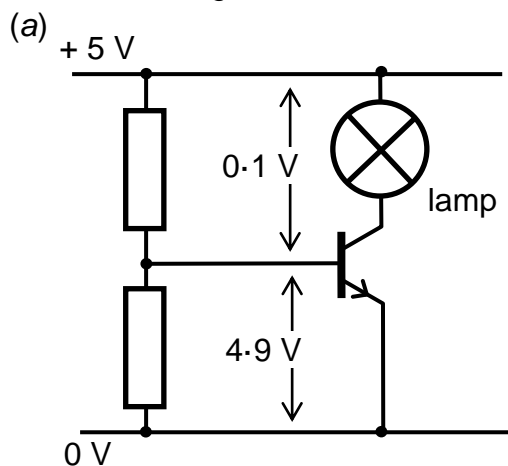
62. Copy the circuit symbol for a NPN transistor and give the full name of the three connections.



63. Here are some statements about NPN transistors. State which are true and which are false.

1. NPN transistors can be used as an electronic switch.
2. NPN transistors are used to convert an a.c. supply to a d.c. supply.
3. NPN transistors are 'switched on' by a voltage between the base and emitter.
4. NPN transistors are 'switched on' by a voltage between the emitter and collector.
5. A NPN transistor which is on conducts through the emitter and collector.
6. A voltage of 0.7 V and above switches on a NPN transistor.
7. NPN transistors conduct very large currents.

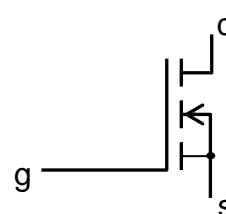
64. For each of the circuits below, state whether the lamp connected to the NPN transistor is alight or not.



65. Look at the circuit symbol opposite.

(a) Name the component.

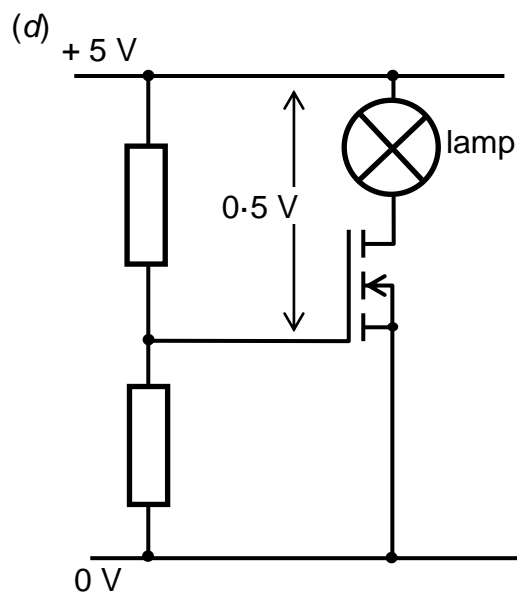
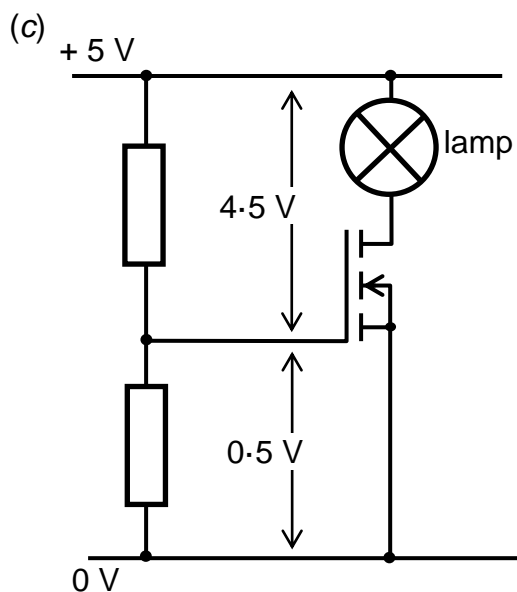
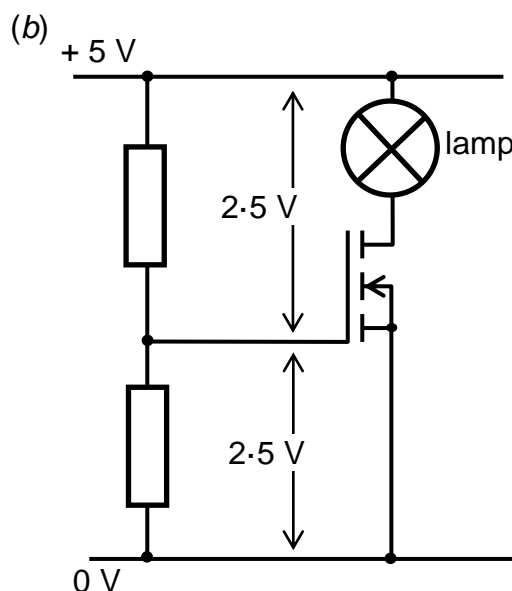
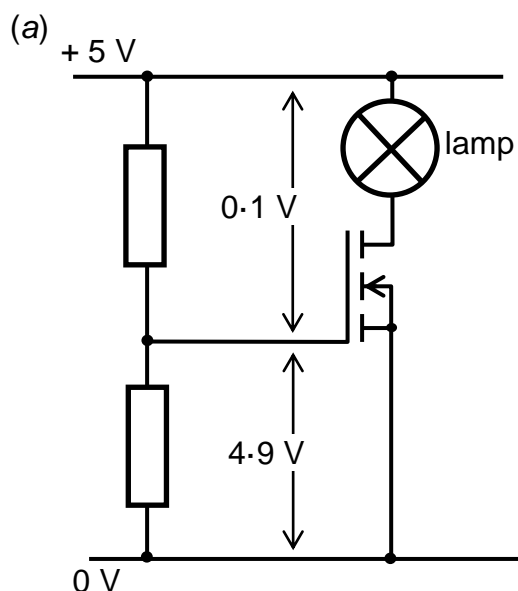
(b) Name the component connections labelled g, d and s.



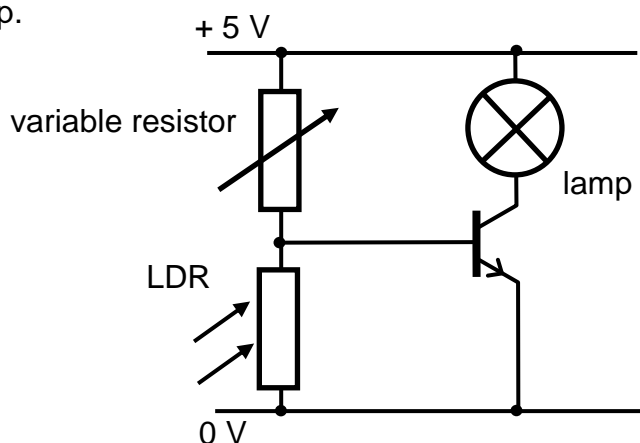
66. Here are some statements about MOSFET transistors. State which are true and which are false.

1. MOSFET transistors can be used as an electronic switch.
2. MOSFET transistors are used to convert a d.c. supply to an a.c. supply.
3. MOSFET transistors are 'switched on' by a voltage between the source and drain.
4. MOSFET transistors are 'switched on' by a voltage between the gate and source.
5. A MOSFET transistor which is on conducts through the source and drain.
6. A voltage of 2.0 V and above switches on a MOSFET transistor.
7. MOSFET transistors conduct very large currents.

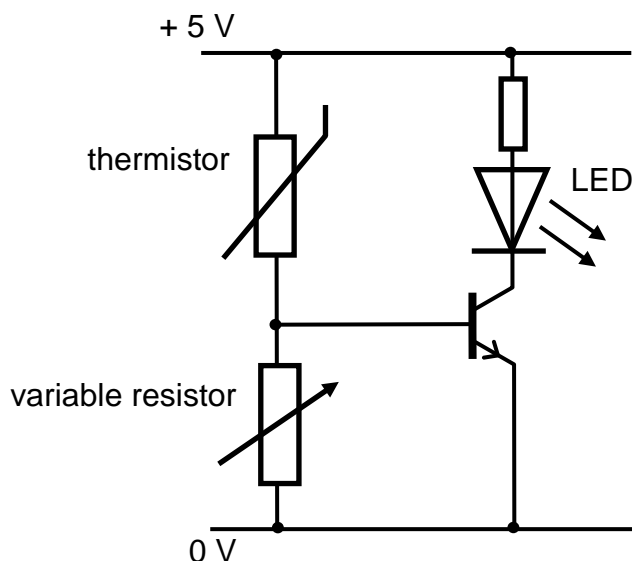
67. For each of the circuits below, state whether the lamp connected to the MOSFET transistor is alight or not.



- 68.** An electronic circuit containing a light dependent resistor is used to switch on a small lamp.



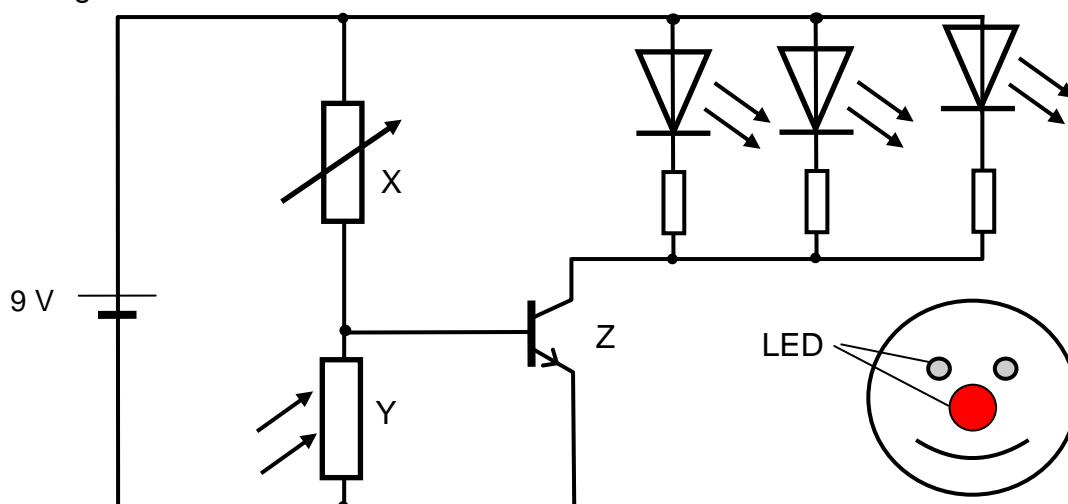
- When will the LDR have the greatest resistance – in the dark or in the light?
 - At night, the variable resistor is adjusted till the lamp just comes on. What must be the minimum voltage across the LDR for this to happen?
 - Why will the lamp switch off when it is daylight?
- 69.** A thermistor is used in a circuit to switch on a LED in a refrigerator if its temperature rises above a pre-set level.



- What happens to the resistance of the thermistor as its temperature rises?
- What will happen to the voltage across the thermistor if its resistance falls?
 - If the resistance of the thermistor falls, what will happen to the voltage across the variable resistor?
- What is the effect on the transistor if the voltage across the variable resistor increases above 0.7 V?
- How can the temperature at which the LED comes on be controlled?

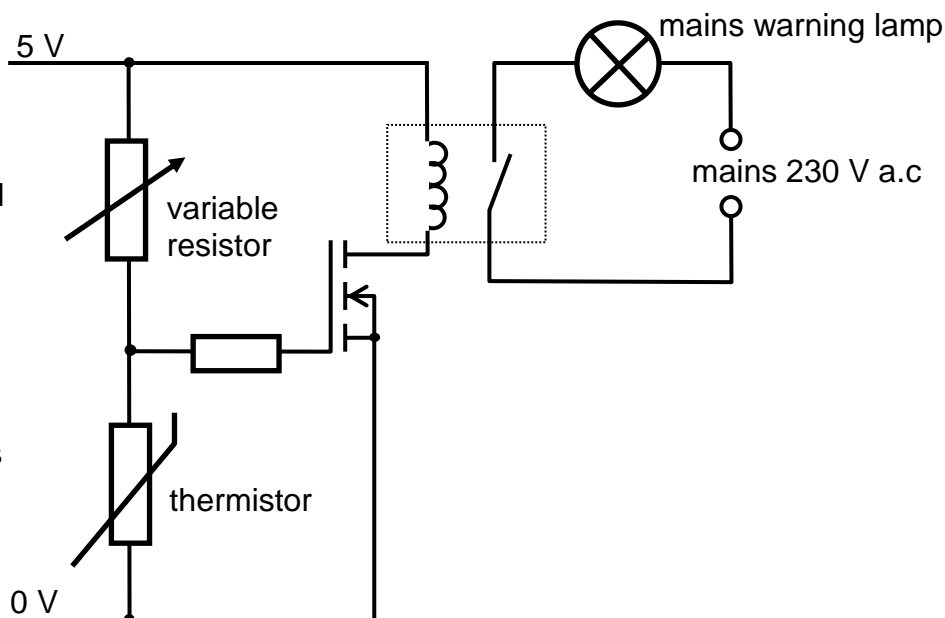
Extension Questions

70. A pupil designs a night light for his little sister. It consists of a happy face with LEDs for the nose and eyes which come on when it gets dark. The circuit for the light is shown below.



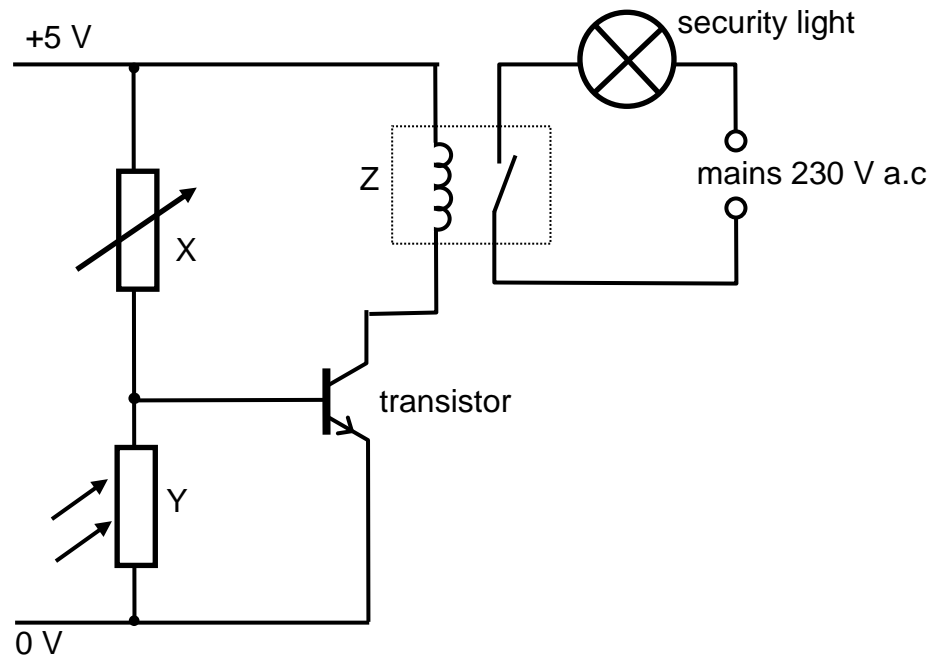
- (a) Name the components labelled X, Y and Z.
- (b) (i) What will happen to the resistance of Y when it is placed in the dark.
 (ii) State what will happen to the voltage across Y as a consequence.
 (iii) Explain the effect this has on the LEDs.
- (c) What would be the effect of reversing the connections to the LEDs?

71. A pupil is asked to design a circuit that will switch on a warning lamp when the temperature in a chilled warehouse rises above a certain value. The circuit she designed is shown opposite. The resistance of the thermistor increases as its temperature increases.



- (a) Explain why the warning light comes on as the temperature of the warehouse rises.
- (b) Explain why MOSFET transistor cannot be used directly to light the lamp.

72. A pupil is asked to design a circuit that will switch on a high powered security spotlight when it gets dark. The circuit she designed is shown below.

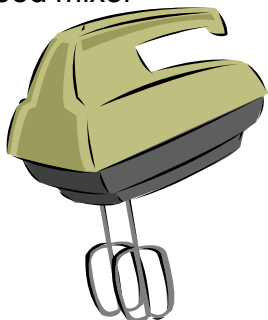


- Name components labelled X, Y and Z.
- Explain why the security light will come on when it gets dark.
- How can the light levels at which the security light comes on be altered?
- Give two reasons why the transistor cannot be used to switch on the security light directly.

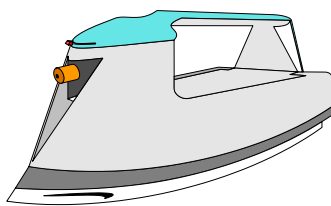
Electrical Power

73. Shown below are three common objects that convert electrical energy.

food mixer



iron



light bulb



- State the energy conversion that takes place for each appliance.
- Give an estimate for the power (joules per second) for each appliance.

74. Several appliances which use electrical energy are listed below.

radio electric oven television table lamp curling tongs.

- Rank the appliances with the one which uses most energy first and the least energy last.
- Possible power ratings for the appliances are given below. Match an appropriate power rating with each appliance.

10 W 8000 W 750 W 300 W 60 W

- What do appliances which have a high power rating have in common?

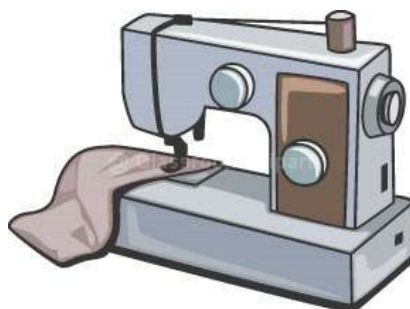
75. State an equation that links power, energy and time.

76. Calculate the missing values in the table below.

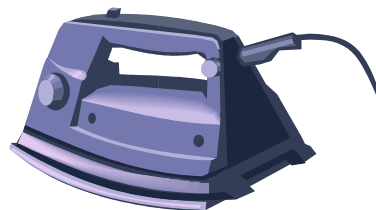
<i>Power</i>	<i>Energy</i>	<i>Time</i>
(a)	100 J	10 s
(b)	2000 J	2 s
40 W	4000 J	(c)
2000 W	120 000 J	(d)
10 W	(e)	100 s
1200 W	(f)	300 s

77. Calculate the power of an appliance which consumes 200 J of energy in 100 s.

78. A sewing machine has a power rating of 100 W. Calculate the time it will operate for on 3000 J of energy.



79. A steam iron consumes 32 000 J of energy in 40 s. Calculate the power of the iron.



80. A washing machine has an average power of 600 W over its wash cycle.

- (a) How many joules of energy are used during a wash cycle lasting 30 minutes.
- (b) At times, the power rating of the washing machine is much higher than the average of 600 W. Suggest a reason for this.

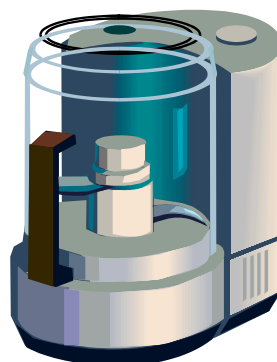


81. State an equation that links power, current and voltage.

82. Calculate the missing values in the table below.

<i>Power</i>	<i>Current</i>	<i>Voltage</i>
(a)	3 A	230 V
(b)	0.5 A	12V
1150 W	5 A	(c)
60 W	5 A	(d)
2.5 kW	(e)	230 V
2 W	(f)	12 V

- 83.** A food processor draws a current of 2 A. Calculate the power of the processor if it is connected to the mains supply at 230 V.



- 84.** A mains appliance draws a current of 6 A. Calculate its power.

- 85.** What current will be drawn by a low voltage 12 V, 50 W light bulb.

- 86.** A small hand held torch has a power of 3 W. Calculate the voltage of the supply if the current to the torch filament is 500 mA.

- 87.** A mains hair drier is rated at 1200 W

- (a) What will be the current to the hair drier when operating at its maximum power?
- (b) The drier contains a fan and heating elements. Which of these will consume the most power?



- 88.** State an equation that links power, current and resistance.

- 89.** Calculate the missing values in the table below.

<i>Power</i>	<i>Current</i>	<i>Resistance</i>
(a)	3 A	30 Ω
(b)	0.5 A	60 Ω
800 W	5 A	(c)
60 W	5 A	(d)
690 W	(e)	76 Ω
6 W	(f)	24 Ω

- 90.** A heating element has a resistance of 57.5 Ω and draws a current of 4 A. Calculate its power.

91. What current will be drawn by a low voltage 48 W light bulb which has a resistance of $3\ \Omega$.
92. A circuit has a resistance of $4\ \text{k}\Omega$. Calculate the power of the circuit if the current flowing in the circuit is $3\ \text{mA}$.
93. A $100\ \Omega$ resistor used in a circuit is rated at $0.5\ \text{W}$. What is the maximum current that can flow through it if used at its maximum rating?
94. A portable camping heater has a power rating of $920\ \text{W}$. It is connected to a mains power point at $230\ \text{V}$.
- (a) What will be the current to the heater when it is operational?
- (b) Calculate the resistance of the heating element.
95. State an equation that links power, voltage and resistance.
96. Calculate the missing values in the table below.



Power	Voltage	Resistance
(a)	$230\ \text{V}$	$40\ \Omega$
(b)	$12\ \text{V}$	$10\ \Omega$
$1000\ \text{W}$	$100\ \text{V}$	(c)
$60\ \text{W}$	$230\ \text{V}$	(d)
$2.0\ \text{kW}$	(e)	$5\ \Omega$
$0.5\ \text{W}$	(f)	$200\ \Omega$

97. An electric fan is connected to the mains at $230\ \text{V}$. Calculate its operational resistance if it has a power of $50\ \text{W}$.



- 98.** An electric kettle is rated at 2.2 kW. Calculate the resistance of the element if it is connected to the mains at 230 V.
- 99.** A low voltage spotlight used in a kitchen operates from 12 V. Calculate the power of the lamp if it has a resistance of $3\ \Omega$.
- 100.** A 12V, 36 W light bulb is connected to a 12 V supply. Calculate the resistance of the filament.

Fuses

- 101.** Draw the symbol for a fuse.
- 102.** By law, the plug of every electrical appliance sold in the UK must have the correct size of fuse fitted. Explain the purpose of the fuse in the plug.
- 103.** What is the danger if too large a fuse being used in a plug?
- 104.** Fuses for plugs are most commonly available as 3 A, 5 A and 13 A values.
- (a) Calculate the current that is normally used by the following appliances and then state which size fuse would be used in the plug. All the appliances are connected to the mains at 230 V.
- (i) A 60 W table lamp.
 - (ii) A 2kW electric heater.
 - (iii) An 800 W microwave oven.
 - (iv) A 500 W fridge-freezer.
- (b) Why would a 3 A fuse be unsuitable for an 850 W mains sandwich toaster?



Image courtesy of John Kasawa/FreeDigitalPhotos.net

Extension Questions

- 105.** (a) A current flows through a resistor in a circuit. It produces 288 J of energy in 2 minutes. Calculate the power of the resistor.
- (b) When electrical energy flows through the resistor it is changed into another form. State what this is.

106. A fan heater operates from the mains. It has a power rating of 2 kW.

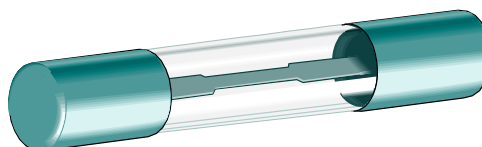
- What is the value of mains voltage?
- Calculate the resistance of the heating element.

107. A physics teacher has a new kitchen installed and decides to find the total power of all the appliances in the kitchen. These are listed below.

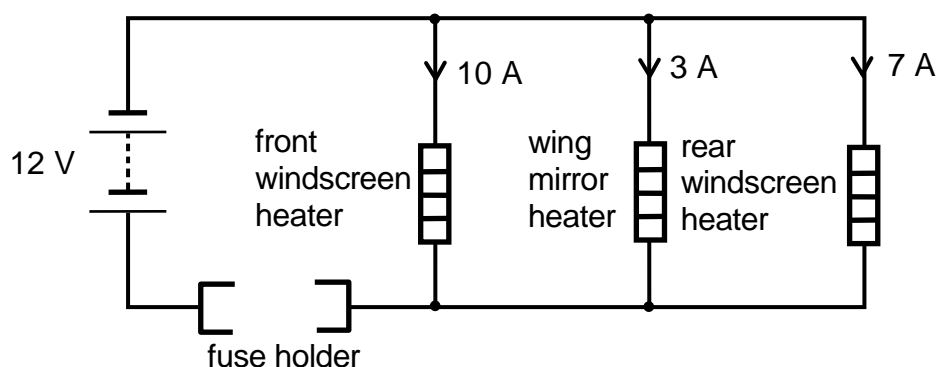
Oven and hob	7000 W
Cooker hood	500 W
Dishwasher	1200 W
Fridge-freezer	450 W
Microwave	700 W
Washing machine	500 W

- Calculate the total power consumption if all appliances are on simultaneously.
- Calculate the total current supplied to the oven and hob.
- Why must the oven and hob have separate cabling rather than being supplied by a mains socket like the other appliances?

108. A car contains several electrical circuits powered from the 12 V car battery. They are protected by a fuse like the one shown opposite.

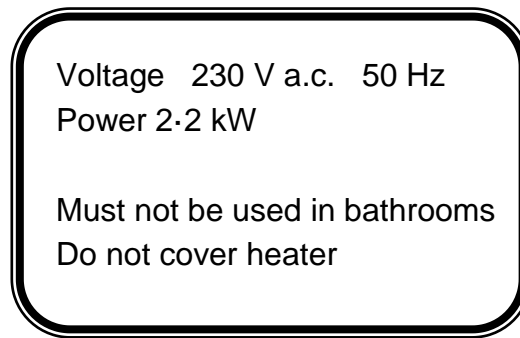


- Draw the circuit symbol for a fuse and state its function in a circuit.
- One circuit in the car supplies power to a range of heating elements in the windscreens and door mirrors as shown below.



- What is the minimum rating of fuse which could be used to protect this circuit?
- Calculate the power of the rear windscreen heater.

109. The rating plate shown below is found on an portable oil filled radiator.



- (a) The flex to the radiator is protected by a fuse in the plug. Calculate the current drawn by the radiator element and state what size of fuse would be appropriate.
- (b) Calculate the resistance of the element.

Conservation of energy

110. State the principle of conservation of energy.

111. A white snooker ball hits a yellow snooker ball head on. The white ball stops and the second ball moves off.



(a) State the energy transfer which took place.

(b) The yellow and white balls have the same mass but the yellow ball moves slightly more slowly than the white ball. Explain why.

112. A hydro-electric power station stores water behind a dam. The water flows downhill through pipes to turn the turbine and generator which produces the electricity.

(a) State the energy change when:

- (i) the water runs down hill through the pipe.
- (ii) the generator produces electricity.

(b) In each instance in part (a), some of the energy is lost. Explain where these energy losses occur in (i) and (ii).

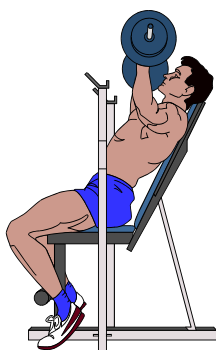
Potential energy

113. State an equation that links potential energy, mass and height.

114. Calculate the missing values in the table below.

Potential energy	Mass	Height	<i>g</i>
(a)	3 kg	20 m	9.8 N kg ⁻¹
(b)	0.5 kg	5 m	9.8 N kg ⁻¹
392 J	2 kg	(c)	9.8 N kg ⁻¹
78.4 J	200 g	(d)	9.8 N kg ⁻¹
147 J	(e)	3 m	9.8 N kg ⁻¹
2.45 J	(f)	0.25 m	9.8 N kg ⁻¹

115. A weightlifter pushes up weights with a mass of 80 kg. Calculate their gain in potential energy if they are raised a height of 0.6 m.



116. A 200 g mass is lifted onto a table. How high must the table be if the mass is to gain 12.25 J of potential energy?

117. A skydiver is at a height of 3000 m. What will be his mass if he has 1.47 MJ of potential energy?



118. On the Apollo missions to the moon in the 1970s, an astronaut dropped a hammer with a mass of 0.8 kg to the ground.

- (a) Calculate the potential energy of the hammer on the earth if it is dropped from a height of 1.5 m.
- (b) If the hammer is dropped from the same height on the moon, what will be its potential energy if the value of g on the moon is 1.6 N kg^{-1}



Kinetic energy

119. State an equation that links kinetic energy, mass and speed.

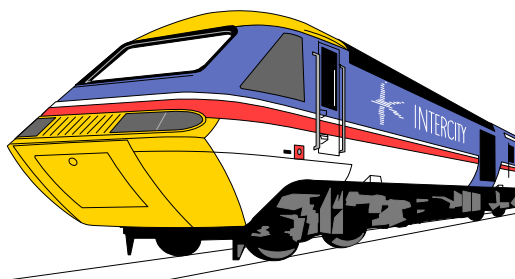
120. A lorry is used to collect waste from houses for recycling.

- (a) Assuming the lorry drives at the same speed, what will happen to its kinetic energy as it collects more and more waste. Give a reason for your answer.
- (b) The lorry increases its speed. How will this affect its kinetic energy?

121. Calculate the missing values in the table below.

<i>Kinetic Energy</i>	<i>Mass</i>	<i>Speed</i>
(a)	2 kg	4 m s ⁻¹
(b)	80 kg	0.5 m s ⁻¹
16 J	4 kg	(c)
1000 J	80 kg	(d)
360 000	(e)	30 m s ⁻¹
2 kJ	(f)	20 m s ⁻¹

122. A train has a mass of 900×10^3 kg. Calculate the kinetic energy of the train if it is travelling at 30 m s⁻¹.



123. Andy Murray can serve a tennis ball at 145 miles per hour which is 65 m s⁻¹. Calculate the kinetic energy of the ball if its mass is 0.058 kg.

124. A car is travelling at 20 m s⁻¹ and has 120 000 J of kinetic energy. Calculate the mass of the car.

125. A ball with a mass of 0.5 kg is released at the top of a slope. It rolls down the slope and at the foot has 2.25 J of kinetic energy.

(a) Calculate the speed the ball was travelling at.

(b) Where did the ball get its kinetic energy from?

126. A fork lift truck is moving packing cases about a factory.

(a) Calculate the kinetic energy of the truck if it is travelling at 0.5 m s⁻¹ and has a total mass of 1800 kg.

(b) If the driver allows the fork lift truck to 'free-wheel' it gradually slows down. Where has its kinetic energy gone to?



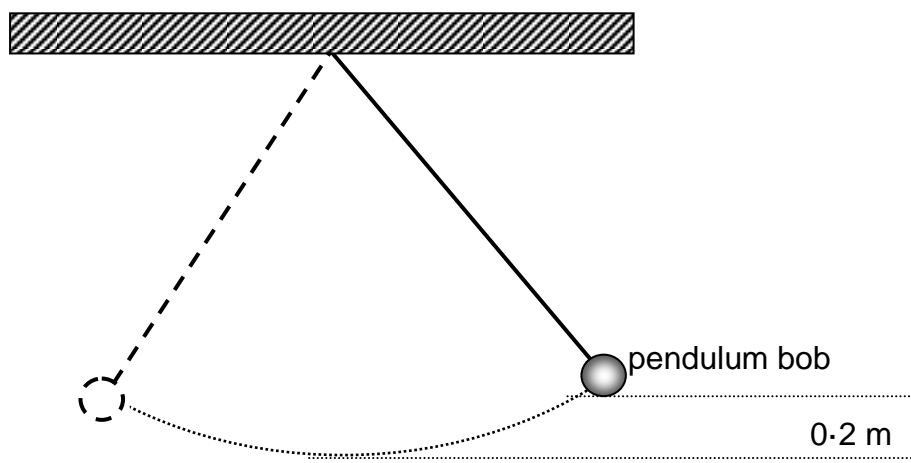
Potential and kinetic energy transfer

127. A student throws a basket ball through the hoop in a game of basket ball. The ball rests on the hoop momentarily before falling through it to the ground. The hoop is 3.0 m above the ground.

- (a) Calculate the potential energy of the ball as it falls through the hoop. The ball has a mass of 0.5 kg.
- (b) Calculate the maximum speed of the ball as it falls to the ground.



128. A pendulum is raised 0.2 m above its rest position as shown below. The pendulum has a mass of 0.2 kg.



- (a) Calculate the potential energy of the pendulum when it is pulled back.
- (b) State the maximum kinetic energy the bob will have as it swings after being released.
- (c) The pendulum does not rise as high on the other side of the swing. Explain why.

129.



A climber has a mass of 60 kg. As she is climbing she slips and falls from the rock face. Fortunately she is attached by a rope.

At the end of her fall, her speed has reached 12 m s^{-1} .

- (a) Calculate the kinetic energy the climber has at the end of her fall.
- (b) Assuming no energy is lost during her fall, what distance did she drop before the rope stopped her?

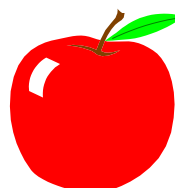
Extension Questions

130. During a game of volleyball, a player knocks a ball vertically into the air.

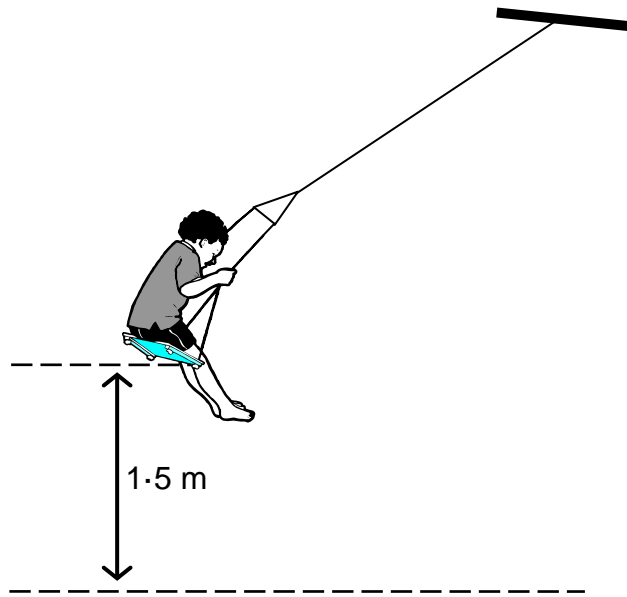
- (a) The ball travels upwards at 8 m s^{-1} . Calculate its kinetic energy if it has a mass of 0.3 kg.
- (b) (i) Calculate the height the ball would reach if there were no energy losses.
- (ii) The height the ball actually reaches is less than that calculated in part (i). Explain why this is.



131. A pupil drops an apple from a height of 1.5 m. Calculate the speed with which it hits the ground assuming there are no energy losses during its fall.



- 132.** A pupil is using a swing in a play park. At the top of his swing he is 1.5 m above the lowest point of the swing. The child has a mass of 20 kg.



- (a) Calculate the potential energy of the child at the top of his swing.
- (b)
 - (i) What will be the kinetic energy of the child at the lowest point of his swing?
 - (ii) Calculate the speed of the child when at the lowest point of his swing.
- (c) The child notices that if he sits still, the swing will never rise up to as high a point as he started from. Explain this observation.

Pressure, force and area

- 133.** An Eskimo wears snow shoes to walk on soft snow. Explain how these are able to stop him sinking into the snow.



- 134.** A sharp knife is able to slice a tomato much more easily than a blunt knife. Explain the physics behind this fact.
- 135.** Ladies stiletto heels may be very fashionable but they are notorious for damaging floors by leaving indentations, especially on wooden flooring. Explain why this happens.
- 136.** State an equation that links pressure, force and area.
- 137.** Calculate the missing values in the table below.

<i>Pressure</i>	<i>Force</i>	<i>Area</i>
(a)	100 N	4 m ²
(b)	20 N	0.5 m ²
50 kPa	750 N	(c)
1 × 10 ⁵ Pa	1000 N	(d)
2 × 10 ⁵ Pa	(e)	0.05 m ²
100 kPa	(f)	0.2 m ²

- 138.** A large book has an area of 0.015 m². Calculate the pressure under the book if the downward pressure it exerts due to its weight is 10 N.
- 139.** A mechanical digger exerts a downwards force of 12 000 N. Its caterpillar tracks cover an area of 3.0 m². Calculate the pressure the digger exerts on the ground.

140. A map pin has a point which has an area of $1 \times 10^{-7} \text{ m}^2$

- What will be the pressure below the point when the pin is pressed with a force of 10 N?
- Explain why a sharp point to the pin makes it very easy to push into a pin board.

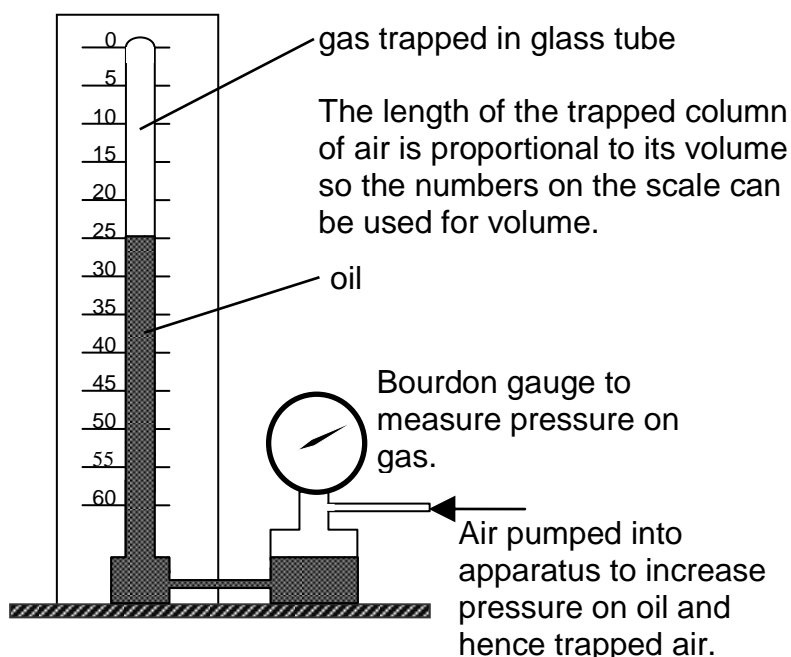


Extension Questions

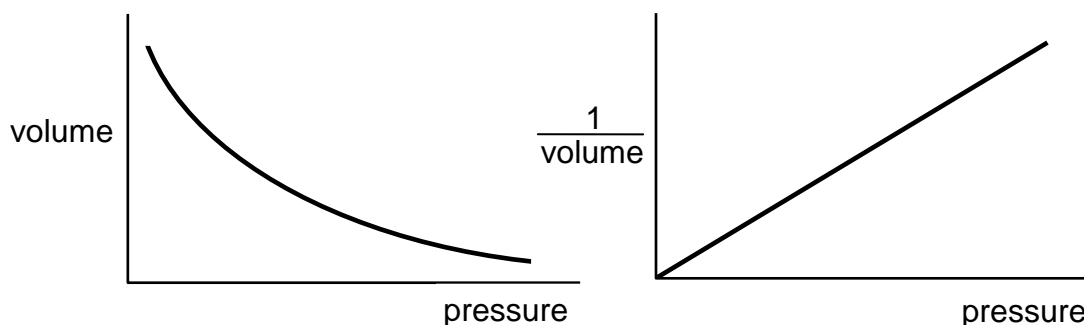
141. A ballerina stands on one toe during a dance. The ballerina has a weight of 450 N. Make suitable estimates of the area of her shoe in contact with the ground and hence calculate the pressure which will be exerted on the floor by her foot.

Pressure and volume

142. A class carries out an experiment to find the relationship between the pressure on a gas and its volume. The apparatus used is shown opposite.



- The volume, temperature and pressure of a gas are all linked. Which quantity is kept constant in this experiment.
- Graphs of pressure against volume and pressure against $\frac{1}{\text{volume}}$ are plotted from the results as shown below. State the relationship between the pressure and volume of the gas in the tube.



143. Give an equation that can be used to relate the changing pressure and volume of a fixed mass of gas.

144. Calculate the missing values in the table below.

<i>Pressure p_1</i>	<i>Volume V_1</i>	<i>Pressure p_2</i>	<i>Volume V_2</i>
$1 \times 10^5 \text{ Pa}$	0.5 m^3	(a)	4 m^3
$2 \times 10^5 \text{ Pa}$	1 m^3	(b)	0.01 m^3
200 kPa	$5 \times 10^{-3} \text{ m}^3$	600 kPa	(c)
1000 kPa	4 litres	50 kPa	(d)
(e)	$1 \times 10^{-3} \text{ m}^3$	$0.5 \times 10^5 \text{ Pa}$	$5 \times 10^{-3} \text{ m}^3$
(f)	2 litres	$2 \times 10^5 \text{ Pa}$	10 litres
50 kPa	(g)	500 kPa	0.5 m^3
15 kPa	(h)	5 kPa	0.2 litres

145. A gas cylinder has a volume of 0.001 m^3 .

The gas it contains is at a pressure of $3 \times 10^6 \text{ Pa}$. Calculate the volume of gas that would be released at atmospheric pressure of $1 \times 10^5 \text{ Pa}$.



146. A scuba diver is working at a depth where the pressure is $4 \times 10^5 \text{ Pa}$.

Bubbles released when she breathes out rise to the surface, expanding as they do so.

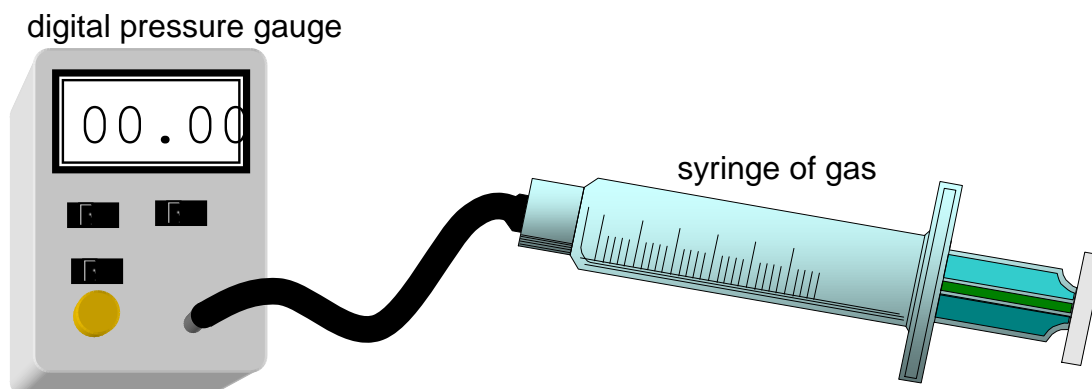
(a) Explain why the bubbles expand as they rise.

(b) The volume of each air bubble as the diver breathes out is $2 \times 10^{-6} \text{ m}^3$. At the water surface the pressure is $1 \times 10^5 \text{ Pa}$. Calculate the volume of each bubble when it reaches the surface.



147. A canister contains 0.002 m^3 of gas at a pressure of $6 \times 10^5 \text{ Pa}$. What will be the volume of the gas at $2 \times 10^5 \text{ Pa}$?

- 148.** A class perform an experiment to find the relationship between the volume and pressure of a gas. A syringe is connected to a digital pressure gauge as shown below.



The pupils record the following results from the experiment.

<i>Pressure in kPa</i>	<i>Volume in cm³</i>	$\frac{1}{\text{Volume}}$
100	14.7	
150	9.9	
200	7.4	
250	5.9	
300	4.9	

- Copy and complete the table by calculating the value of $1/\text{volume}$ for these results.
- Plot a graph of pressure against $1/\text{volume}$ and state the relationship between them.
- Calculate the gas pressure in the syringe if its volume was reduced to 2 cm^3 .

Kelvin scale

- 149.** When dealing with gases and temperature, a temperature scale called the Kelvin scale is used. Each division on the Kelvin scale is the same size as divisions on the Celsius scale.

- The temperature of a gas increases by 20°C . What is the increase in temperature of the gas in Kelvin?
- What temperature is 0 K in degrees Celsius?

150. Convert the following temperatures from the Celsius scale to the Kelvin scale.

- (a) 0°C
- (b) 27°C
- (c) 127°C
- (d) -273°C
- (e) -173°C
- (f) 77°C
- (g) -127°C
- (h) 346°C
- (i) 18°C
- (j) 100°C

151. Convert the following temperatures from the Kelvin scale to the Celsius scale.

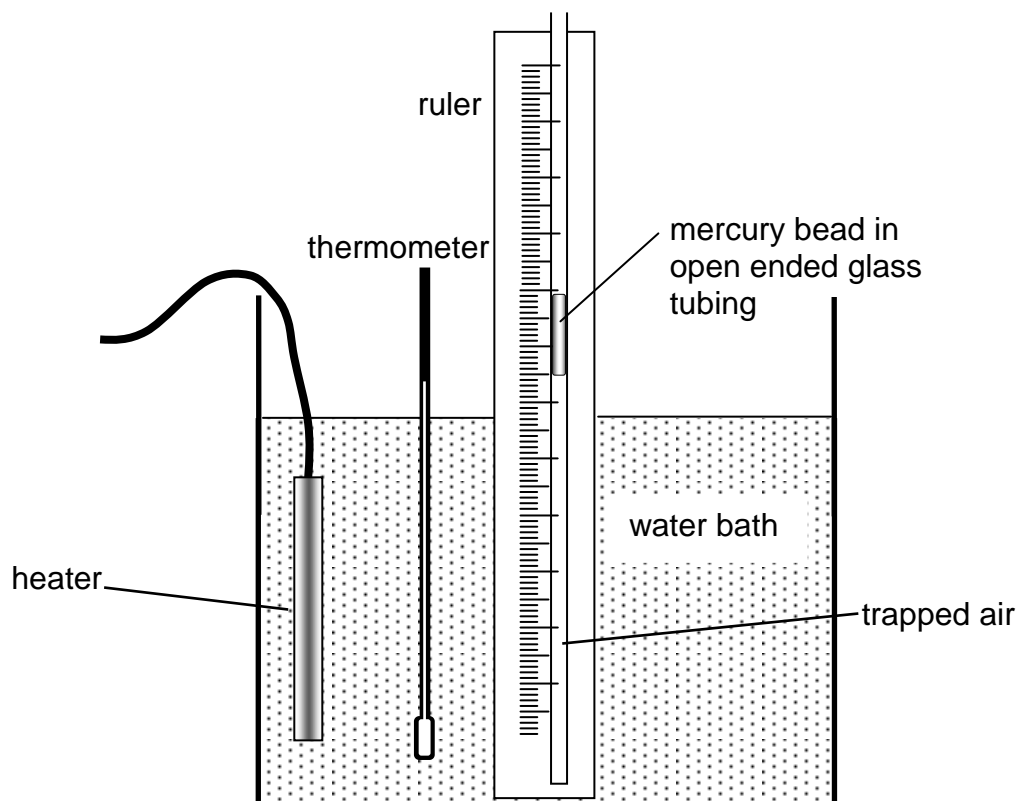
- (a) 0 K
- (b) 273 K
- (c) 293 K
- (d) 300 K
- (e) 373 K
- (f) 173 K
- (g) 323 K
- (h) 50 K
- (i) 623 K
- (j) 450 K

152. Explain what is meant by the temperature 'absolute zero'.

153. What is the temperature of 'absolute zero' in the Kelvin and Celsius scales?

Volume and temperature

154. The relationship between temperature and volume can be investigated using the apparatus shown below. A mass of air is trapped in a glass tube by a bead of mercury. The mercury is free to move as the air expands. The length of the trapped air is proportional to its volume.



Some pupils record the following results from the experiment.

<i>Temperature in °C</i>	<i>Temperature in K</i>	<i>Volume (length of air column)</i>
20		21.5
40		22.9
60		24.4
80		25.9
100		27.3

- (a) Copy and complete the table by calculating the temperature of the air in Kelvin.
- (b) Plot a graph of volume against temperature in Kelvin and state the relationship between them.

154. (continued)

- (c) The teacher tells the pupils that the set up of the experiment could be improved. Make a suggestion of how this could be done.
- (d) The temperature of the water is cooled by adding ice and salt to the water. This lowers the temperature of the trapped air to $-10\text{ }^{\circ}\text{C}$. Calculate the length of the gas column at this temperature.

155. Give an equation that can be used to relate the temperature and volume of a fixed mass of gas.

156. Calculate the missing values in the table below.

<i>Volume V_1</i>	<i>Temperature T_1</i>	<i>Volume V_2</i>	<i>Temperature T_2</i>
0.5 m ³	200 K	2.0 m ³	(a)
6 litres	300 K	(b)	600 K
(c)	350 K	0.02 m ³	250 K
2 litres	(d)	12 litres	300 K
0.5 m ³	27 $^{\circ}\text{C}$	2.0 m ³	(e)
1.5 m ³	17 $^{\circ}\text{C}$	(f)	127 $^{\circ}\text{C}$
(g)	27 $^{\circ}\text{C}$	5 m ³	327 $^{\circ}\text{C}$
4 litres	(h)	30 litres	27 $^{\circ}\text{C}$

157. A sealed syringe contains 20 cm³ of air at a temperature of 27 $^{\circ}\text{C}$.

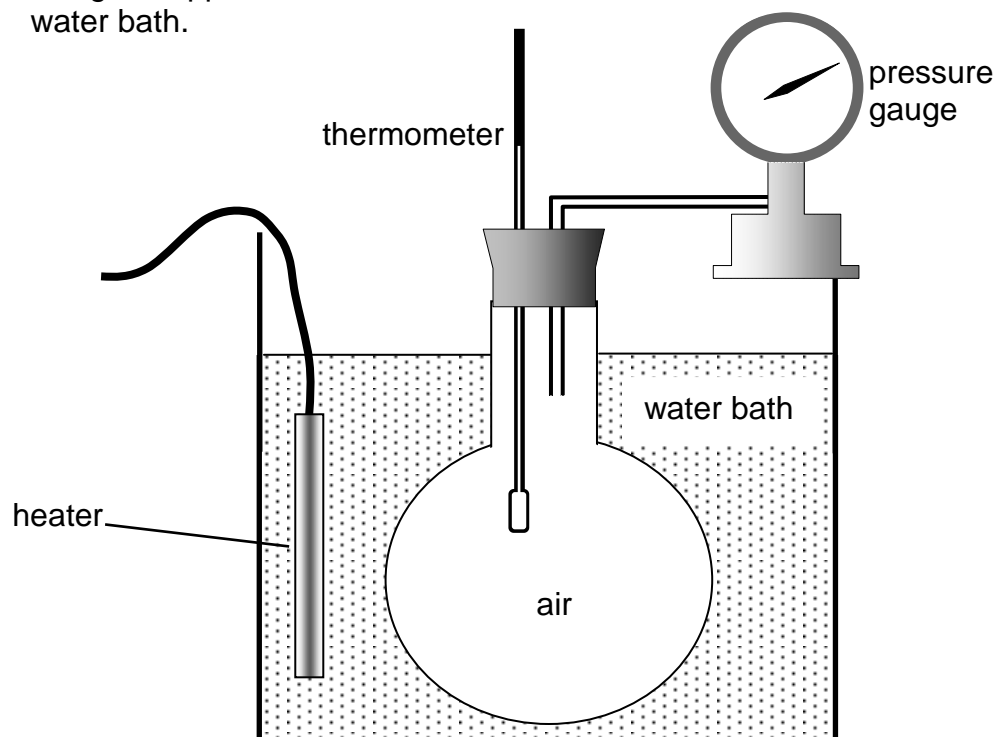
- (a) Convert the temperature into the Kelvin scale.
- (b) Calculate the new volume the air in the syringe will occupy if the plunger can freely move and the syringe is placed in hot water at a temperature of 77 $^{\circ}\text{C}$.

158. A gas occupies a volume of 10 litres at a temperature of 300 K. What volume would it occupy at 600 K?

159. A mass of gas occupies 1 m³ at a temperature of 27 $^{\circ}\text{C}$. Assuming no change in pressure, what would be the volume of the gas if it expanded at a temperature of 227 $^{\circ}\text{C}$?

Pressure and temperature

160. The relationship between temperature and pressure can be investigated using the apparatus shown below. A mass of air in a flask is heated in a water bath.



Pupils record the following results from the experiment.

<i>Temperature in °C</i>	<i>Temperature in K</i>	<i>Pressure in kPa</i>
10		100
20		104
30		107
40		111
50		114
60		118

- (a) Copy and complete the table by calculating the temperature of the air in Kelvin.
- (b) Plot a graph of pressure against temperature in Kelvin and state the relationship between them.

160. (continued)

(c) Although pressure and temperature varied in this experiment, two factors were kept constant. What were these?

(d) By looking at the diagram of the apparatus used, can you suggest two ways in which the experiment could be improved to obtain more accurate results.

161. Give an equation that can be used to relate the temperature and pressure of a fixed mass of gas.

162. Calculate the missing values in the table below.

<i>Pressure p_1</i>	<i>Temperature T_1</i>	<i>Pressure p_2</i>	<i>Temperature T_2</i>
$2 \times 10^5 \text{ Pa}$	300 K	$4 \times 10^5 \text{ Pa}$	(a)
100 kPa	200 K	(b)	600 K
(c)	350 K	$5 \times 10^5 \text{ Pa}$	250 K
$2.0 \times 10^5 \text{ Pa}$	(d)	$1.8 \times 10^5 \text{ Pa}$	300 K
200 kPa	27 °C	800 kPa	(e)
$1 \times 10^5 \text{ Pa}$	17 °C	(f)	127 °C
(g)	27 °C	150 kPa	327 °C
$1 \times 10^5 \text{ Pa}$	(h)	$4 \times 10^5 \text{ Pa}$	27 °C

163. A motorist checks the pressure of the air in his car tyre on a cold morning and finds it is $3.0 \times 10^5 \text{ Pa}$. The temperature of the air in the tyre is 2 °C. After a journey on the motorway the temperature of the air has risen to 57 °C. Calculate the pressure of the air now.

164. A cylinder of gas is at a temperature of 17 °C. The gas is at a pressure of 100 kPa. Calculate the pressure of the gas if its temperature rises to 75 °C.

165. A mass of gas is held in a flask at –20 °C and a pressure of 89 kPa. Calculate the pressure of the gas if its temperature rises to 60 °C.

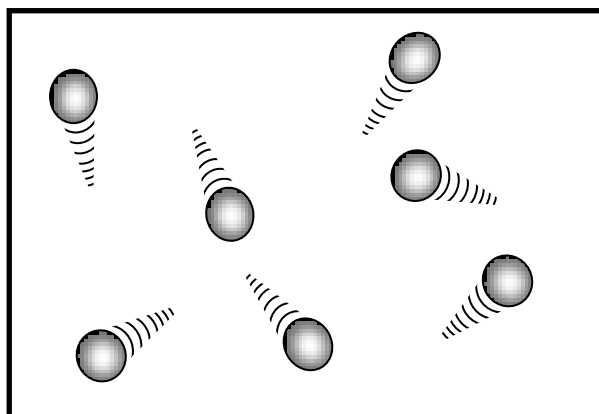
166. A gas cylinder holds gas at a temperature of 27 °C at a pressure of $5.0 \times 10^5 \text{ Pa}$. A safety valve will operate at $9.0 \times 10^5 \text{ Pa}$ if the gas heats up. At what temperature would this occur?

Kinetic model

167. Which of the following statements about a gas is/are true or false.

- A. A gas has a fixed shape and a fixed volume.
- B. A gas has a fixed shape but not a fixed volume
- C. A gas has a fixed volume but not a fixed shape.
- D. A gas has neither a fixed shape or volume.
- E. The particles in a gas can increase and decrease in size.
- F. The particles in a gas can increase and decrease in speed.

168. The diagram opposite shows how gas particles in a container. (particles greatly enlarged)



- (a) What will happen to when the particles collide with the walls of the container?
- (b) The temperature of the gas is raised. How does this affect the movement of the gas particles?
- (c) (i) What happens to the pressure inside the container if the gas is heated?
(ii) Explain why any changes in the pressure take place.

169. A metal canister of gas is cooled. State the effect has this on the pressure inside the container and explain your answer.

170. A weather balloon is made of a very stretchy material and filled with helium gas.

- (a) As the balloon rises, how will the pressure inside the balloon compare with the pressure outside.
- (b) The air at higher altitudes is 'thinner'. What will happen to the volume of the balloon as it rises?



171. Explain, in terms of the kinetic theory of gases, why a gas trapped in a cylinder causes pressure.

172. Air is pumped into a car tyre. Explain why this increases the pressure in the tyre.
173. An empty aluminium drinks can is attached to a vacuum pump. As the air is pumped out of the can, the sides of the can collapse. Explain, in terms of the kinetic theory of gases, why this happens.
174. Explain, using the kinetic theory of gases, why a gas will expand as its temperature increases.

Extension questions

175. A diver carries a gas cylinder with a volume of 0.015 m^3 . The air it contains is at a pressure of $2 \times 10^7 \text{ Pa}$.

- (a) Calculate the volume of air available to her at a depth where the pressure is $4 \times 10^5 \text{ Pa}$.
- (b) As the diver heads for the surface, she finds she has to breathe out continuously. Explain why this happens.



176. A mass of gas is held in a sealed container.
- (a) The temperature of the gas is increased. Sketch the graph of pressure against temperature in Kelvin for the gas.
- (b) Use the kinetic theory of gases to explain the changes in pressure which take place.
- (c) The pressure of the gas in the container is $2.8 \times 10^5 \text{ Pa}$ at a temperature of 27°C . What would be the pressure of the gas if its temperature was raised to 127°C ?
177. The catering galley of an aircraft is stocked on the ground with sealed cartons of Pringles. The volume of the packaging gas in the cartons is 180 cm^3 and the air pressure on the ground is 100 kPa .

- (a) When flying at its cruising altitude the cabin pressure in the aircraft is 80 kPa . Calculate the volume the packaging gas would occupy at this pressure if allowed to freely expand.
- (b) The packaging gas is contained in the cardboard carton. The lid of the carton is pushed outwards. Explain, in terms of the kinetic theory of gases, why this happens.



- 178.** An equation known as the General Gas Equation can be used to solve problems where pressure, volume and temperature all change. The equation is

$$\frac{p_1 V_1}{T_1} = \frac{p_2 V_2}{T_2}$$

Use the general gas equation to solve the following problems. (Remember to convert temperatures to the Kelvin scale if appropriate).

- (a) A fixed mass of gas occupies 3 litres at a pressure of 200 kPa and a temperature of 300 K. Calculate the volume of the gas if the pressure is reduced to 100 kPa and its temperature increased to 600 K.
- (b) A bubble of gas escapes from the sea floor where the temperature is 1 °C and the pressure 20×10^6 Pa. At the sea surface the temperature is 17 °C and the pressure 1×10^5 Pa. Calculate the new volume of the bubble if its volume on the sea floor was 1×10^{-9} m³.
- (c) During an experiment in a science class, a student collects 0.45 litres of hydrogen chloride gas at a pressure of 100 kPa and at a temperature of 17 °C. Calculate the volume of the gas at 0 °C and 101.3 kPa?

Specific Heat Capacity

- 179.** Copy and complete the paragraph on heat and specific heat capacity using the words given below.

mass heat temperature kinetic specific

The _____ of a substance is a measure of the average _____ energy of the molecules of the substance. Temperature can be measured directly using a thermometer.

_____ is the amount of thermal energy a substance contains, measured in joules. The amount of heat energy a substance contains depends upon a number of factors including its temperature and _____. Different substances also require different amounts of energy to produce a particular rise in temperature. This is called their _____ heat capacity.

Specific heat capacity is defined as the energy required to raise the temperature of 1 kg of the substance by 1 °C. If heat energy is added to a substance its molecules gain kinetic energy and as a result the temperature of the substance rises.

180. Give an equation that relates heat energy, change in temperature, mass and specific heat capacity.

181. Calculate the missing values in the table below.

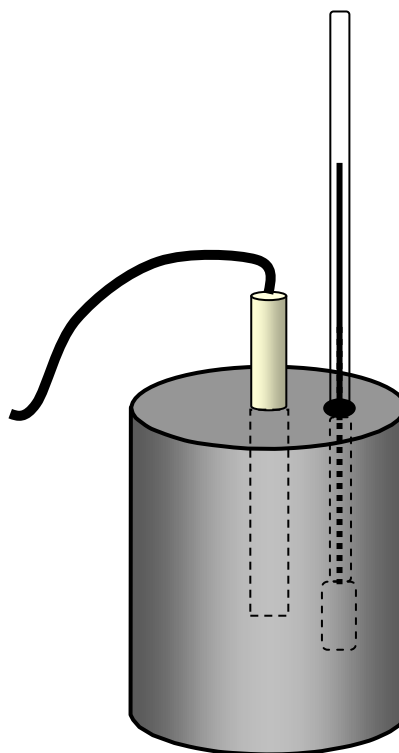
<i>Energy added</i>	<i>Specific heat capacity</i>	<i>Mass</i>	<i>Change in temperature</i>
(a)	$4180 \text{ J kg}^{-1} \text{ }^{\circ}\text{C}^{-1}$	2 kg	$20 \text{ }^{\circ}\text{C}$
3608 J	(b)	0.1 kg	$40 \text{ }^{\circ}\text{C}$
8000 J	$500 \text{ J kg}^{-1} \text{ }^{\circ}\text{C}^{-1}$	(c)	$80 \text{ }^{\circ}\text{C}$
31 500 J	$2100 \text{ J kg}^{-1} \text{ }^{\circ}\text{C}^{-1}$	3 kg	(d)
(e)	$530 \text{ J kg}^{-1} \text{ }^{\circ}\text{C}^{-1}$	0.2 kg	$18 \text{ }^{\circ}\text{C}$
4800 J	$2400 \text{ J kg}^{-1} \text{ }^{\circ}\text{C}^{-1}$	100 g	(f)

182. A copper block has a mass of 1.3 kg. Calculate the energy required to raise its temperature from $25 \text{ }^{\circ}\text{C}$ to $45 \text{ }^{\circ}\text{C}$ if copper has a specific heat capacity of $380 \text{ J/kg}^{\circ}\text{C}$.

183. A hot water bottle contains 0.8 kg of water at a temperature of $70 \text{ }^{\circ}\text{C}$. How much energy will the bottle lose if its temperature falls to $40 \text{ }^{\circ}\text{C}$? (specific heat capacity of water = $4180 \text{ J kg}^{-1} \text{ }^{\circ}\text{C}^{-1}$)

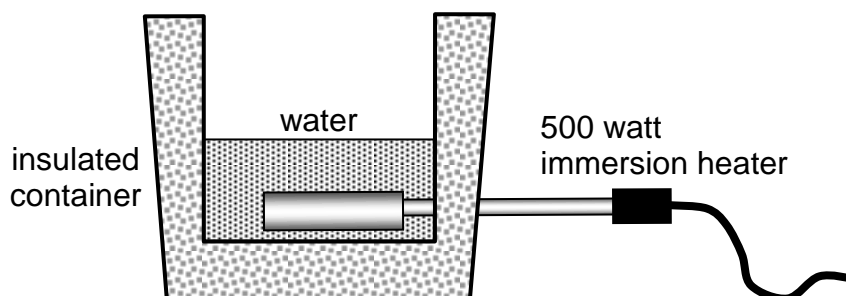
184. A pupil adds 10 000 J of energy to an aluminium block using an electrical heater. The block has a mass of 1 kg.

- (a) The temperature of the block increases from $20 \text{ }^{\circ}\text{C}$ to $28 \text{ }^{\circ}\text{C}$. Calculate the specific heat capacity of aluminium using the results from this experiment.
- (b) The pupil looks up a data sheet to discover the correct value is $902 \text{ J/kg}^{\circ}\text{C}$. Give a reason why his calculated value may have been incorrect.



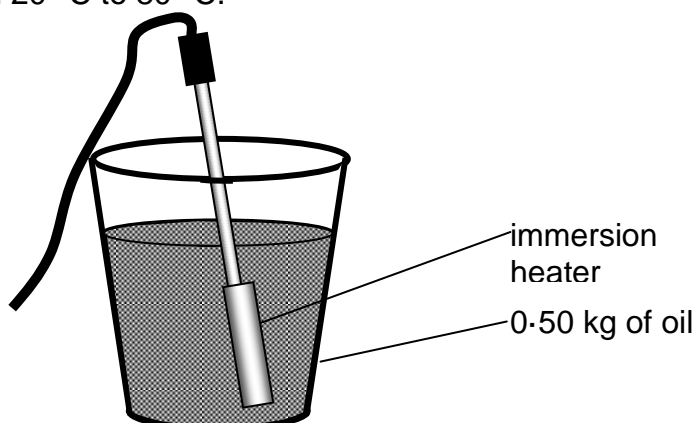
Extension questions

185. A small container of water is surrounded by thick insulation. The container holds 0.3 kg of water at a temperature of 20 °C. A 500 W immersion heater is placed in the water.



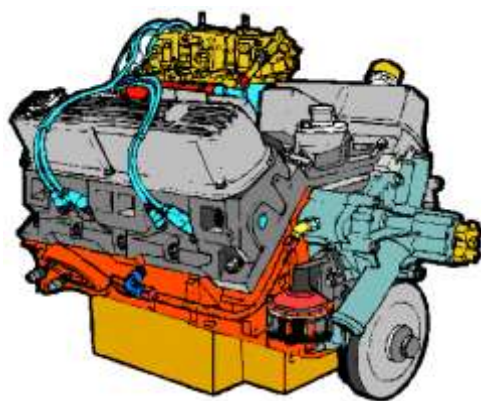
- Calculate the heat energy required to raise the temperature of the water to 60 °C. (Specific heat capacity of water = 4180 J kg⁻¹ °C⁻¹)
- Calculate the time it will take to produce this increase in temperature assuming no energy is lost to the surroundings.
- Even though the container is insulated, heat is still lost to the surroundings. State one way in which this loss could be reduced.

186. A beaker contains 0.5 kg of oil. An electric heater rated at 500 W is used to heat the oil from 20 °C to 80 °C.



- Calculate the heat energy added to the oil if the heater is switched on for 180 s.
- Calculate the value of the specific heat capacity of the oil that these results give.
- The actual value for the specific heat capacity of the oil is 2000 J kg⁻¹ °C⁻¹. Give a reason why the answer obtained from the experiment was not accurate.

- 187.** A mains immersion heater is used to heat the water in a hot water tank. It holds 200 kg of water.
- (a) Show, by calculation, that 29.26 MJ of energy will be required to raise the temperature of the water by 35 °C. The specific heat capacity of the water is 4180 J/kg°C.
 - (b) The immersion heater operates at 230 V and draws a current of 30 A.
 - (i) Calculate the power of the heater.
 - (ii) How long does it take the heater to heat the water assuming no heat is lost?
 - (c) Although 29 MJ of energy went into raising the temperature of the water, the actual energy required to be produced by the heater was 36.25 MJ due to energy losses. Calculate the percentage efficiency of the process.
- 188.** A car engine is kept cool by water being pumped around the engine block, losing the heat picked up at the car radiator.



- (a) The mass of the water in the cooling system is 3.0 kg. Calculate its rise in temperature if the energy removed is 960 000 J. (Specific heat capacity of water = 4180 J/kg°C)
- (b) A new coolant has a specific heat capacity of 3000 J/kg°C. Would you expect this to be more or less effective at removing heat from the engine. Give reasons for your answer.

Reducing Energy waste

189. A leaflet explains ways in which a householder can save energy and reduce their energy bills.

- (a) Look at the suggestions listed below and for each one, describe how it will be able to reduce the energy being used.
- A. Turn out the lights when not in the room.
 - B. Don't overfill your kettle.
 - C. Only use a dishwasher when full.
 - D. Insulate your walls and loft.
 - E. Don't leave appliances on standby.
 - F. Reduce the use of labour saving electrical gadgets.
 - G. Choose energy efficient appliances.
 - H. Fit double glazing.
 - I. Fit insulation around the hot water storage tank.
 - J. Have showers instead of baths.
 - K. Switch energy supplier.
 - L. Turn down room thermostats.

(b) Which of the advice above is likely to save most money?

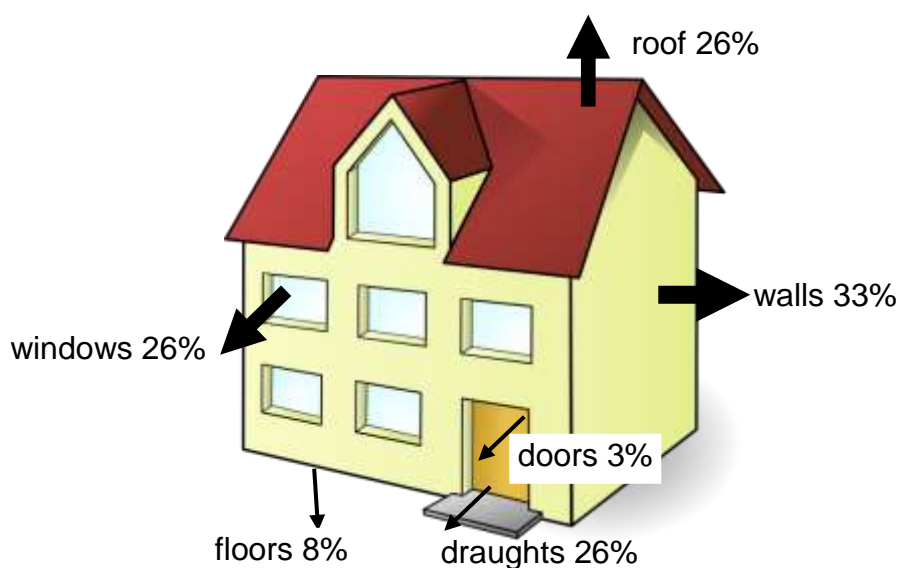
190. Thermal images can be used to show the heat being lost through different parts of a house. Light areas of the image are hotter and dark areas colder. In the image below, the block of flats on the right of the picture is newly built. The flats on the left behind the trees was built in the 1970s.



Photograph by Passivhaus Institut

- (a) Which area(s) of the modern block is losing most heat?
- (b) Which block, the new or the older, is losing most heat? Suggest a reason for your answer.

191. The diagram below shows the typical energy losses from a house.



- (a) Where is most energy lost from the house?
- (b) The householder spends £1500 each year on heating the house. Listed below are some of the energy saving measures that could be installed and their cost. Suggest which you would be most likely to choose if you were the householder and give reasons for your choice.

Measure	cost
Fit draught excluders	£120
Insulate roof	£300
Lay carpets in downstairs rooms	£1200
Replace doors	£1500
Fit double glazed windows	£8000
Insulate walls with cavity foam	£5500