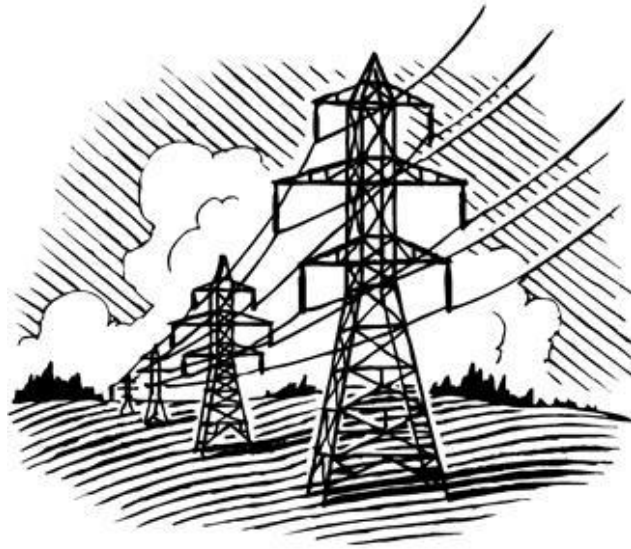# Cathkin High School
PHYSICS
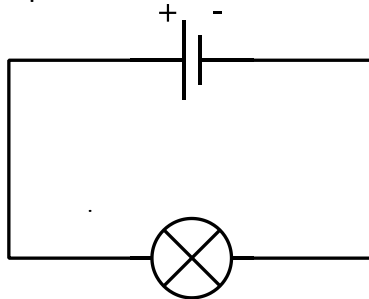# National 4 and 5

Homework

Unit 2-Electricity and Energy
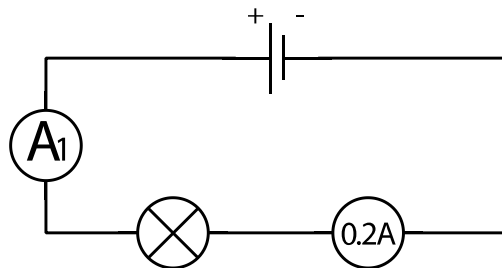
Practical Electricity

Exercise 1

1a)   Redraw the following circuit and add an ammeter which will measure the current
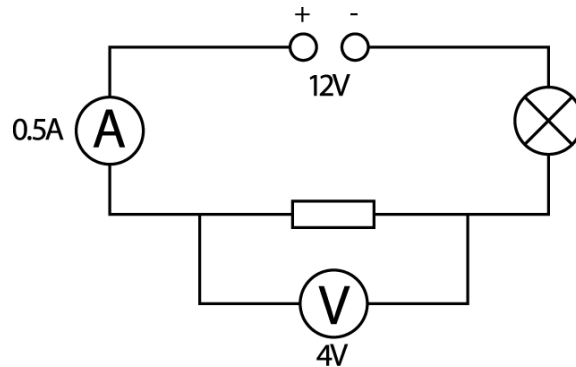   flowing through the lamp.

b)   Add a voltmeter which will measure the voltage across the lamp

2   In the following circuit, what is the reading on ammeter A1?

3a) Write down the rule for the current at all points in a series circuit.
 b) Write down the relationship between the supply voltage and the potential difference
      (voltages) across the individual components in a series circuit.

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

5a)   Which of the following statements is/are true for **series** circuits
  b)   Which of the following statements is/are true for **parallel** circuits
              A   There is only one pathway round the circuit.
              B   There is more than one pathway around the circuit.
              C   The potential differences around the circuit add up to
                        the supply voltage.
              D   The potential difference (voltage) is the same across all
                         components.
              E   The current is the same at all points in the circuit.
              F   The current through each component adds up to the
                        supply current.

6   In the circuit below the ammeter reading is 0.5A and the
    voltmeter reading is 4V.

        a) State whether this is a series or parallel circuit.
      b) i) What is the current through the lamp?
        ii) What is the potential difference across the lamp?

7   In the circuit below the ammeter reads 0.8A, the current
    through the lamp is 0.3 A and the voltmeter reads 6V.
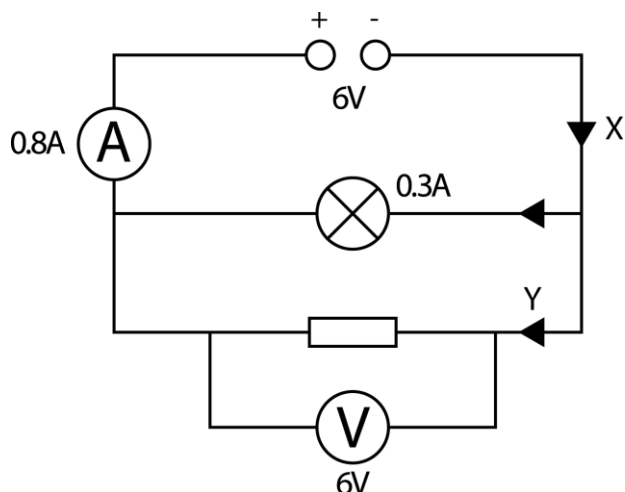
    a) Is this a series or parallel circuit?
    b) i) What are the current values at X and Y?
        ii) What is the potential difference across the lamp?

Exercise 2
1   Copy and complete the following sentences using these words
   *Amperes, electrons, current*
     A conductor is a material in which _____ are free to move. When electrons
     move in one direction in a electrical circuit a _____ is produced. Current is
     measured in _____.

2   The current in an electric heater is 7A. How many coulombs of charge will flow through
   the heater in 30 seconds?

3   An electric hairdryer is on for 5 minutes. The current to the hair dryer is 3A. How much charge flows to the hair dryer?

4   A charge of 12 C passes through a lamp every 6 seconds.
     Calculate the size of the current flowing through the lamp.

5   A switch is closed for 10 minutes. If 3600 C pass through the switch in this time, what is the current flowing in the switch?

6   A car headlamp gets a current of 2A. How long does it take for 50C to pass through it?

7   A battery stores 150 000 C of electric charge. For how long can it supply a current of 50A?
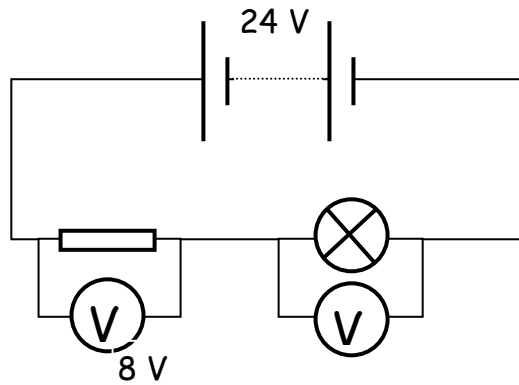
Exercise 3

1   In the circuit below, the voltmeter reads 4 volts.
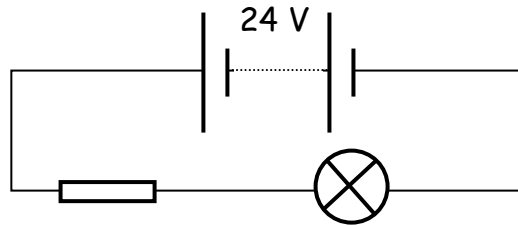   What is the voltage across the resistor R?
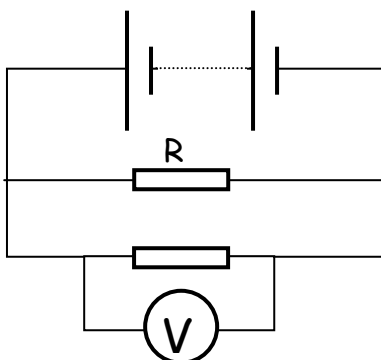
2.   In the circuit below, the voltages are as shown.
      Calculate the voltage of the supply.
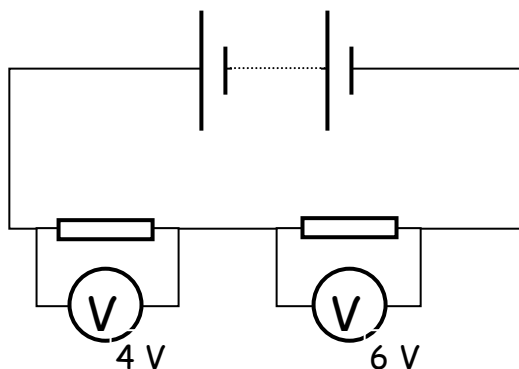
3. In this circuit, the voltages are shown. What is the voltage across the bulb?

24 V

V
8 V

V

4. This diagram shows a 6 V bulb working correctly off a 24 V supply. What must be the voltage across the resistor?

24 V

5. The diagram shows the circuit of the courtesy light in a two-door car.

A car Courtesy Light operates when either door of the car is opened

6 V

S_1

S_2

Courtesy Light
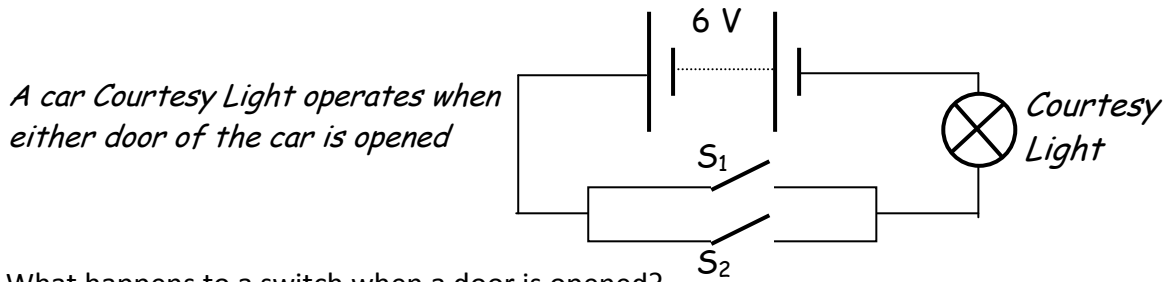
a) What happens to a switch when a door is opened?
b) Explain why the switches are in parallel rather than in series.

Exercise 4

1 Copy and complete the following paragraph using the words from the
   list below.

   One, d.c., direct , alternating, a.c. , opposite
   When a battery is connected to an electrical circuit, electrons move in _____
   direction around the circuit. Since the current only passes in _____ direction it is
   called _____ current
   (____).
   When a mains supply is connected to an electric circuit, electrons move in one
   direction, then in the _____ direction and then back again. This to and fro
   movement of the current is called _____current (____)

2 Copy and complete the oscilloscope pictures for the circuits below.

CRO

CRO
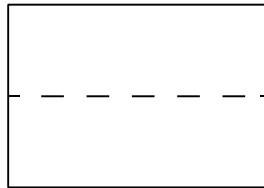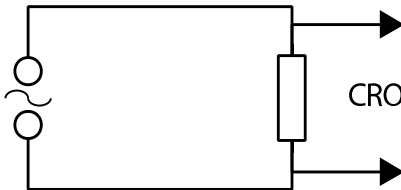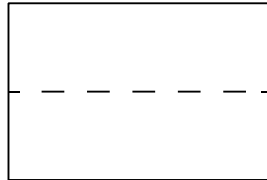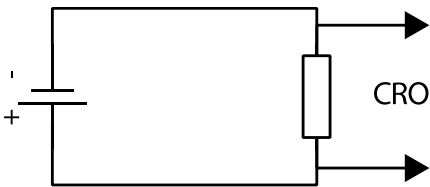
3   From the circuits shown in the diagrams below.
    What are the missing ammeter readings A1, A2, A3 and voltmeter readings V1, V2 and
    V3?

a)
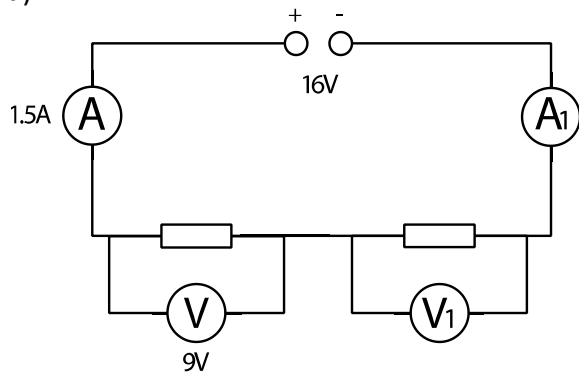
b)

c)
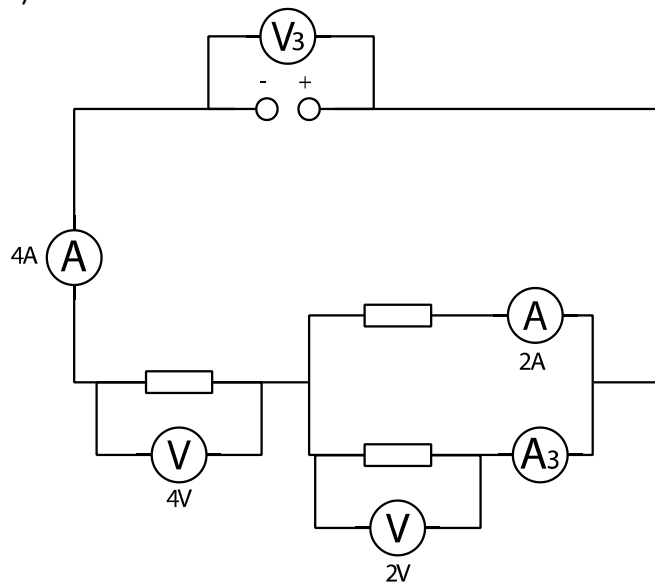
4   Copy and complete the paragraph below using the words from
        the list below.
                    ohms ,resistance, decreases, heat, electrical

        The opposition to the flow of current is called _____.
        Resistance is measured in _____. Increasing the resistance of a circuit
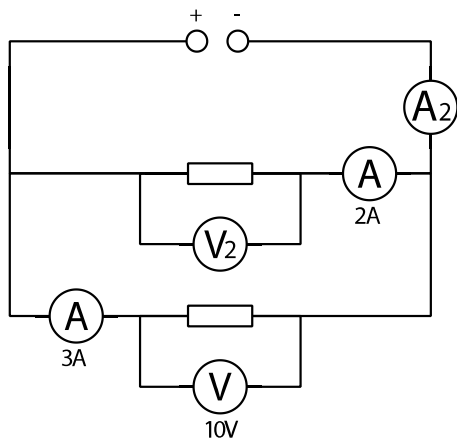   _____ the current in the circuit. When a current passes through a resistor,
        _____ energy is changed into _____ energy.

5   (a) Name three factors that affect resistance.
    (b) For each factor describe how the resistance is affected.
    (c) Give two examples of where variable resistors are used.

Exercise 5

1   This circuit was connected up to verify ohm's law.
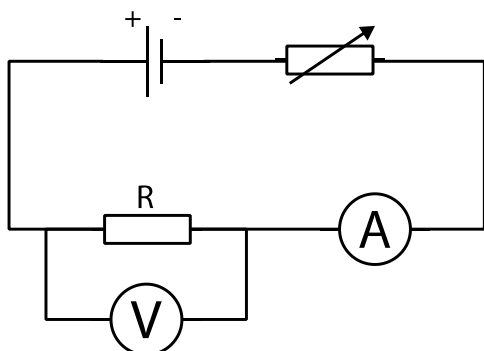
        The current and voltage of R are varied and the results are shown in the table:

Voltmeter Reading	2V	4V	6V	8V	10V	12V
Ammeter Reading	0.4A	0.78A	1.22A	1.64A	2.02A	2.35A

        a) Explain how the current and voltage were varied
        b) Plot a line graph of voltage against current on graph paper.
        c) Explain whether your graph verifies ohm's law.
        d) From your graph, find the value of resistor R

2   In the following circuits, calculate the resistance of the lamp.

2A   24V

3V   15mA

4V   0.3A
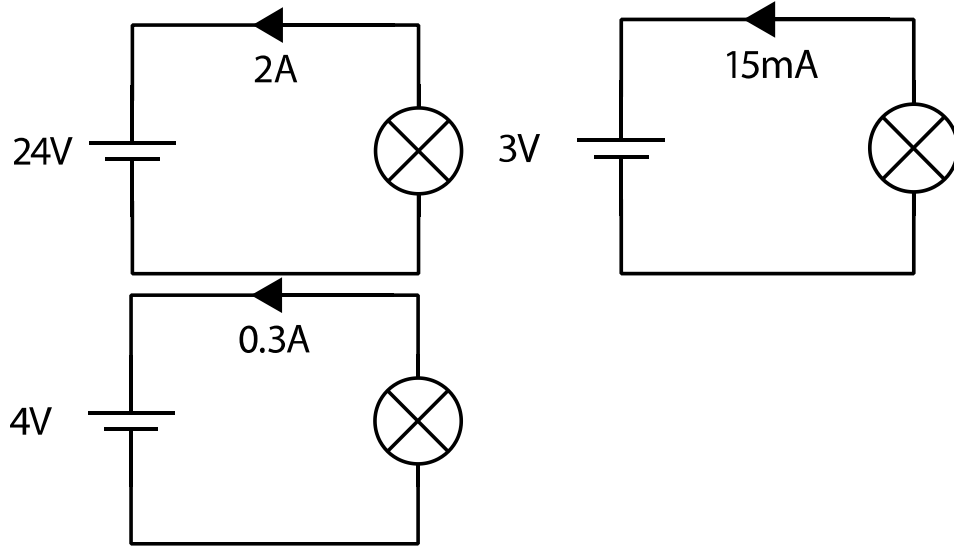
3   Calculate the value of the unknown in the following circuit

a)

9Ω

(A) A

12V

b)

6Ω

(A) 2A

c)

R

(A) 3A

12V
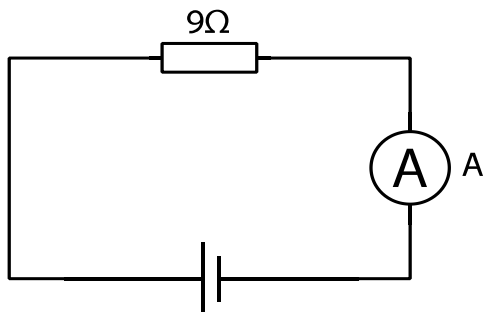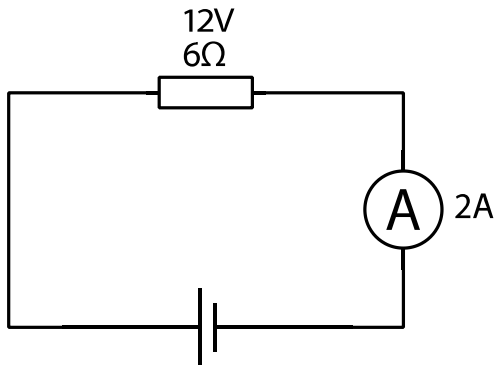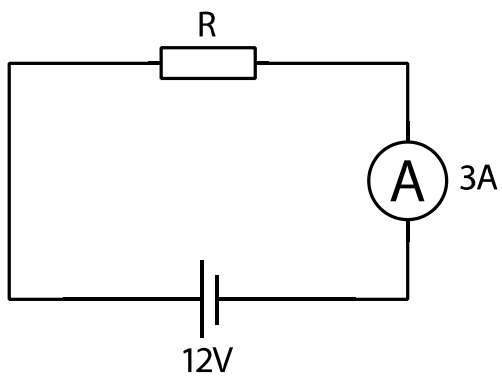
d)
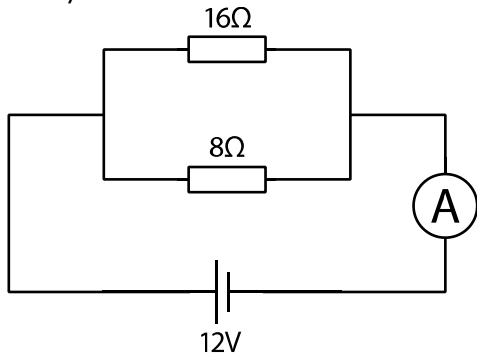
e)
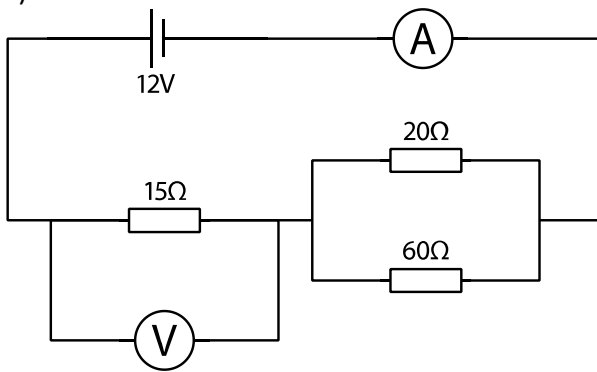
Exercise 6

1. Find the total resistance between points X and Y in each of the circuits below.

a
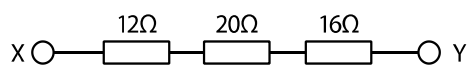
b
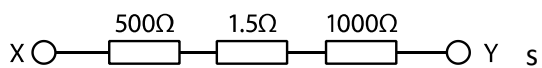
c
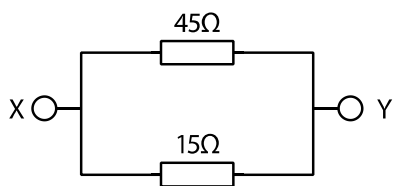
d
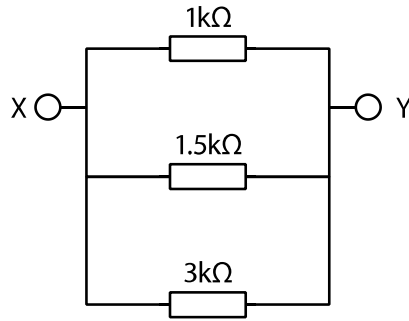
e
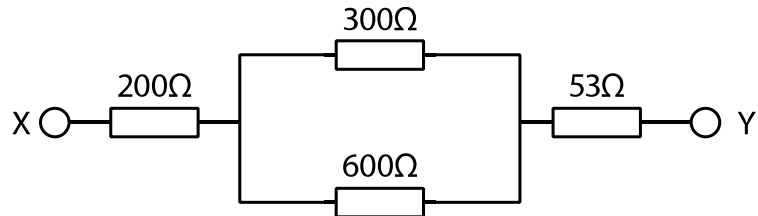
2. A resistor has a voltage across it of 12 volts and a current through it of 2 amperes. Calculate the resistance of the resistor.

3. A voltage of 6 volts is across a resistor where the current is 0.5 amperes. Calculate the value of the resistor in Ohms.

4. Calculate the resistance of a component when a voltage of 24 V causes a current of 0.1 amperes.

5. If a current of 2 amperes flows through a lamp when 12 volts across it. What is the resistance of the lamp?

6. A torch bulb is marked "6 V, 0.25 A". Calculate the resistance of the bulb.

7. A resistor is placed in a circuit. The voltage across it and current through it are measured as 12 volts and 0.02 amperes.

   The resistor is now removed from the circuit and connected to an ohmmeter. What is the reading on the ohmmeter?

8 a) Find the values of the resistors in the circuit below.

0.25 A

2 V   3 V   5 V
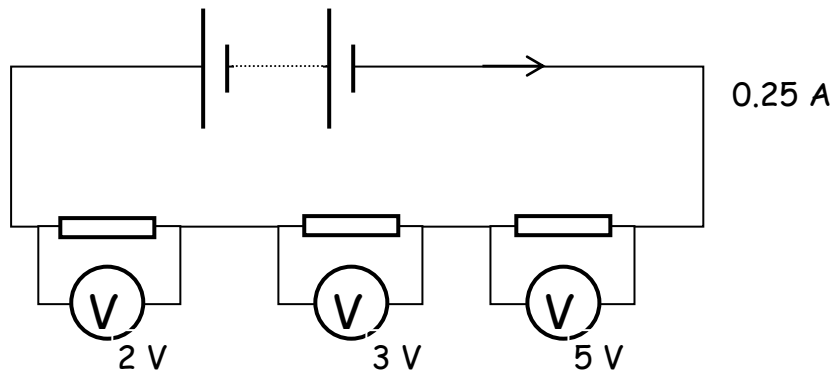
c) Calculate the value of the supply voltage in this circuit.

2.2 Electrical Power

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

2. The electric motor on a ceiling fan uses 207 kJ of electrical energy in 30 minutes.
a) Calculate the power rating of the motor in the fan.
b) State the energy changes involved when the ceiling fan is switched on.

3. Give the number of joules in:
a) 1 MJ
b) 1 GJ
c) 500 kJ
d) 450 GJ

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

5. What is the power rating of an appliance which transforms:
a) 500 J in 5 s
b) 1200 J in 20 s
c) 1.8 MJ in 10 minutes?

6. How much electrical energy is used by the following appliances?
a) A 400 W drill used for 45 s
b) A 300 W food processor used for 20 s
c) An 800 W iron used for 40 minutes
d) A 2.4 kW kettle that takes 5 minutes to boil the water inside it.

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

8. A power station has an output power of 640 MW.
How much electrical energy does it produce in 1 min?

9. The electrical power requirement of the United Kingdom is 95 GW.
How much electrical energy is used in 1 day?

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

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

12. Using the formula: I=P/V, calculate the current for the following appliances (and then choose its fuse from this list: 2A, 3A, 5A, 10A, 13A)
a) Iron - 1000W, 230V;
b) CD player – 100W, 230V;
c) Dishwasher – 2500W, 230V;
d) Vacuum Cleaner – 600W, 230V;
e) Table Lamp – 60W, 230V;
f) Kettle – 2900W, 230V;
g) Toaster 2000W, 230V;
h) Stereo system 15W, 230V.

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

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

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

16. A 100 Ω resistor has a maximum safe power rating of 4 W. Calculate the maximum current it can safely handle.

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

18. By combining the equations $V = IR$ and $P = VI$, show that the power can also be given by $P = V^2/R$
.
19. Calculate the power rating of a heater which has a resistance of 53 Ω working off the mains voltage of 230 V.

2.3 Electromagnetism

1.The diagram below shows the direction of a magnetic field around a current carrying wire.

Direction of magnetic field.

End view of wire

Current into paper.
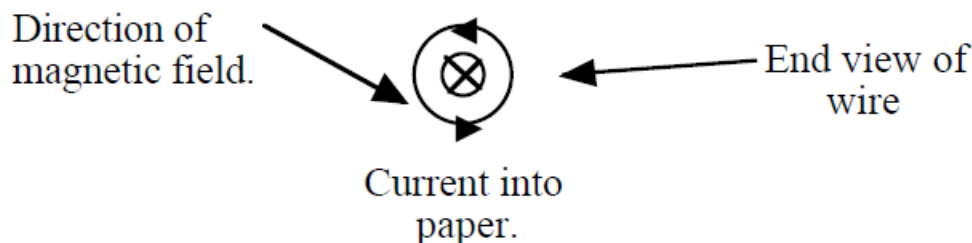
Copy and complete the diagram below showing the direction of the magnetic fields around both current carrying wires.

Current   Current
In   Out
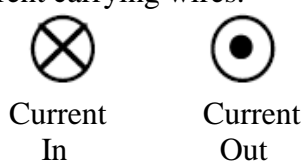
2. a) Explain how a voltage could be induced in a coil of wire.
b) Give three methods of increasing the size of this induced voltage.

3. Give 4 uses of transformers in every day life.

4. A magnet is moved into a coil of wire which is attached to a centre zero galvanometer as shown.
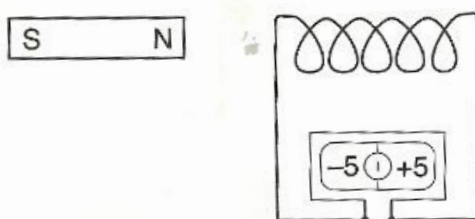
Moving the North Pole in makes the galvanometer reading change from zero to +5 on the scale.
   a) What happens to the reading when the magnet stops inside the coil?
   b) What happens to the reading when the magnet is moved out again (at the same rate as before)?
   c)   What happens to the reading when the magnet stops outside the coil?
   d) What difference does it make to the current reading if the magnet is moved slowly or quickly into the coil?

5. Write down the relationship between the voltages and number of turns in the coils of a transformer.

6. An engineer requires a transformer to step down a voltage from 3000 V to 230 V. Calculate the required turns ratio.

7. The diagram shows the main parts of an a.c. generator.

a) Copy the diagram and mark in the: Input, Output, Rotor, Stator Coil.
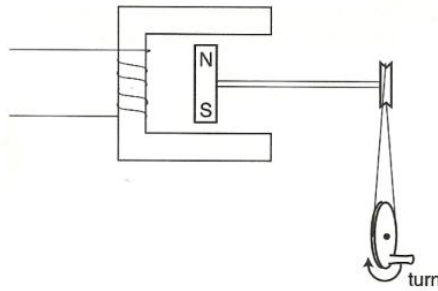
b) Explain how electricity is produced.

Answers (Electrical Power, Electromagnetism)
Electrical Power

1. a) Electrical to Heat.
   b) Kettle, hair dryer, straightener, oven.

2. a) 115 W

3. a) 1 000 000 J (1 X 10^6 J)
   b) 1 000 000 000 J (1 X 10^9 J)
   c) 500 000 J (5 X 10^5 J)
   d) 450 000 000 000 J (45 x 10^{10})

4. a) 60J

5. a) 100 W
   b) 60 W
   c) 3000 W

6. a) 18000 J
   b) 6000 J
   c) 1.92 x 10^6J
   d) 7.2 x 10^5J

7. 50 s

8. 3.84 x 10^{10}J

9. 82.08x10^{14}J

10.
 b) 3.6W
 c) 12960J

11. a) 1.3 A
    b) 8.64 x 10^6 J

12. a) 4.35 A, fuse 5A

b) 0.43 A, fuse 2A
c) 10.87 A, fuse 13A
d) 2.61 A, fuse 3A
e) 0.26 A, fuse 2A
f) 12.61 A, fuse 13A
g) 8.7 A, fuse 10A
h) 0.07 A, fuse 2A

13. b) 1920 W

14. a) 24 W
   b) 48 W

15. a) 8.7 A
   b) 26 Ω

16. 0.2 A

17. 60 Ω

19. 998 W

2.3 Electromagnetism

1. Current in: the direction of the magnetic fields - anticlockwise
   Current out: the direction of the magnetic fields – clockwise

2. a) A voltage may be induced when a coil of wire is moved within a magnetic field.
   b) By increasing the strength of the magnetic field, increasing the number of coils of wire
and increasing the speed of the movement.

3. In relation to transmission lines; in cell phone, bike lights, laptops (battery-powered
devices that have the capability of being recharged by plugging them into an outlet).

4. a) Reading goes to zero.
   b) Reading changes from zero to -5 on the scale.
   c) Reading goes to zero.
   d) Moving the magnet quickly produces a larger current (but for a shorter time).

5. V_s/V_p = Ns/Np

6. Ns/Np = 13/1

7. b) Spinning the rotor means lines of force are cutting the stator coils. Current is produced
in the coil.

2.4 Generation of Electricity

Renewable and non-renewable fuels

1. What is our main source of energy at present?

2. What are **fossil** fuels?

3. Name three important fossil fuels.

4. Why do these substances make good fuels?

5. 'The reserves of fossil fuels are **finite**'.   Explain clearly what this statement means.

6. Give two disadvantages of fossil fuels.

7. Fossil fuels are non-renewable.   Write down two other fuels that are non renewable?

8. List 7 sources of renewable energy and describe how electricity is produced from them.

9. Write down one advantage and one disadvantage of each of these sources of renewable energy.

10. A small island generates 10 GW of electrical power from three renewable energy sources.   Wind energy generates 50% of the electrical power, wave energy produces 35% of the electrical power and the remaining 15% electrical power is obtained from solar cells.
    (a) How many watts are there in 1GW (one gigawatt) of electrical power?
    (b) How many gigawatts of electrical power are generated from each renewable energy source?

11. Energy converters can be used to obtain energy from waves. The power levels available are, on average, 50 kilowatts for every metre of wavefront.
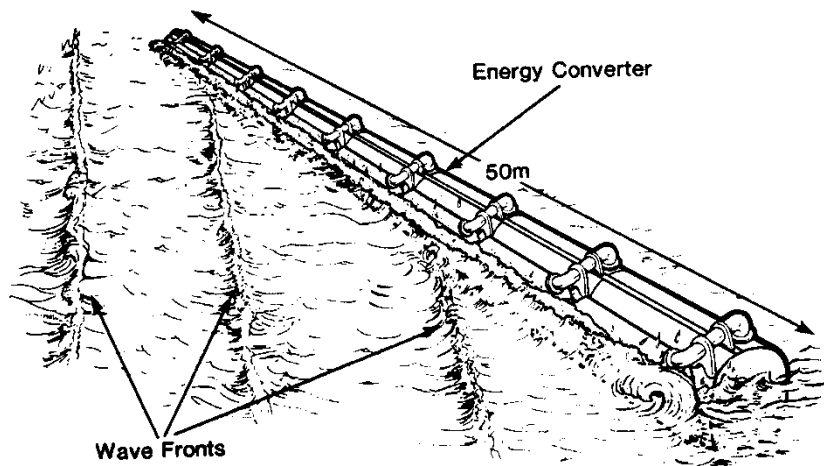
(a) How much power is available if an energy converter covers 50 metres of wavefront?
(b) Only 25% of this power is available as electricity. How much electrical power can be produced by this energy converter?
(c) What length of wavefront would be required to provide a small town with 10 megawatts of power (1 megawatt = 1000 kilowatts).

12. A wind generator has been constructed on Orkney by the North of Scotland Hydroelectric Board. Its rotor blades rotate and cover a circle of area 2800 m^2 perpendicular to the wind.

The diagram shows the power available per square metre across various parts of the country.
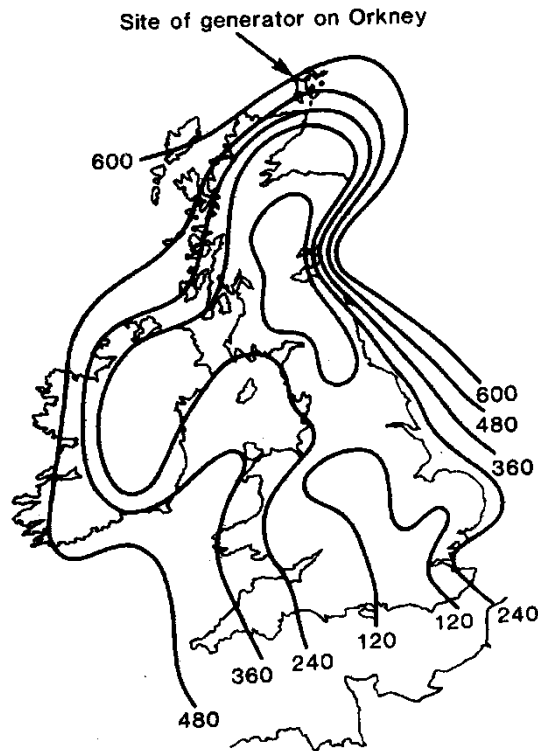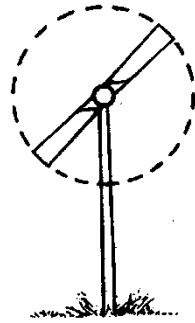
(a) Explain why Orkney is a good site for a wind generator.
(b) Calculate the maximum average power available from the wind generator when it is facing the wind.

Transformers

1. What is a transformer?

2. Copy this diagram of a transformer and label the parts:
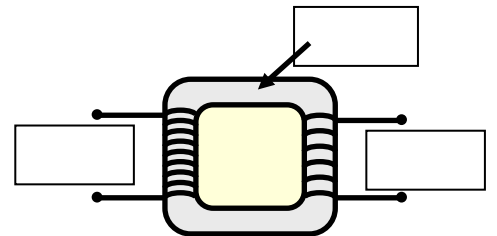
3. a) Explain how a voltage could be induced in a coil of wire.
   b) Give three methods of increasing the size of this induced voltage.
4. List three electrical devices which have transformers inside them.

5. Explain why a transformer will only give a continuous output when used with a.c.

6. Write down the relationship between the voltages and number of turns in the coils of a transformer.

7. Use the above relationship to solve the problems below:

$V_p = 10$ V $V_s = ?$ $V_p = 100$ V $V_s = ?$ $V_p = 100$ V $V_s = ?$

100 turns   300 turns   100 turns   300 turns   200 turns   50 turns

V_p = 20 V V_s = 5V V_p = 240 V V_s = 12 V V_p = 2 V V_s = 24 V
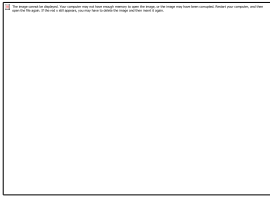
100 turns   ? turns   400 turns   ? turns   40 turns   ? turns

V_p = 240 V V_s = 12 V_p = 240 V V_s = 48 V_p = 12 V V_s = 480 V

? turns   200 turns   ? turns   800 turns   ? turns   2000 turns

V_p = ? V_s = 300 V V_p = ? V_s = 100 V V_p = ? V_s = 440 V

400 turns   1000 turns   2000 turns   20000 turns   200 turns   800 turns
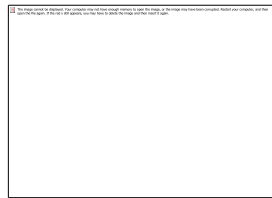
8. Complete the following table:

Primary Coil		Secondary Coil	
Voltage	Number of turns	Voltage	Number of turns
12 v a.c.	200		400
20 V a.c.	500		250
230 V a.c.	1000		500
	300	50 V a.c.	30
12 V a.c.	60	48 V a.c.	
230 V a.c.		1840 V a.c.	8000

9. Describe what is meant by an ideal transformer.

10. Give two reasons why transformers are not 100% efficient.

Transmission of electricity

1. (a) What is the **National Grid** and what does it transmit around the country?

   (b) Why must **very high voltages** be used by the National Grid to transmit electricity over long distances?

2. The diagram below represents how electricity reaches our homes. Name and state the

purpose of numbers 1, 2, 3, 4 and 5.
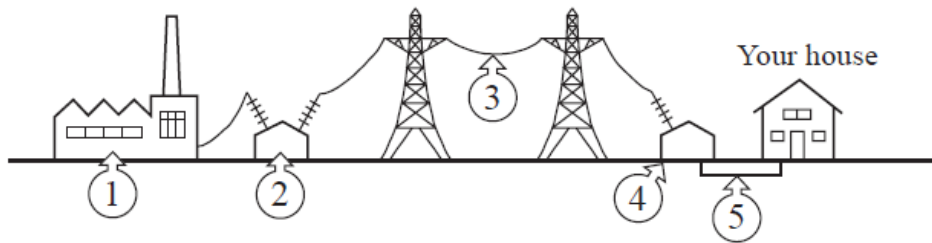
3. An engineer requires a transformer to step down a voltage from 3000 V to 230 V.
    If there are 4600 turns on the primary coil, calculate the number of turns needed on the secondary coil.

4. Calculate the turns ratio required for a step down transformer with an input voltage of 11 kV on the primary coil and an output voltage of 230 V on the secondary coil.

5. The power losses (in watts) due to heating in a current carrying electricity cable can be calculated using the formula $P = I^2 R$

    (a) Calculate the power losses in a cable of resistance 28 Ω that carries a current of 0.3 A
    (b) A wire has a resistance of 4 Ω.   Calculate the current in the cable if its power losses are 6.4 W.
    (c) What is the resistance of a cable in which the power losses are 0.8 watts when it carries a   current of 200mA?

6. 50 kW of power is to be transmitted through long cables to a small village.   The cables have a total resistance of 0.5 Ω.   Calculate the **power lost** in the cables if the power is delivered to the cables at (a) 250 V a.c. and (b) 250 kV a.c., after being stepped-up by a transformer.

7. A circuit diagram for a model power line is shown below.   Bulb 1 represents the 'power station' and bulb 2 represents the 'town'.   The current and voltage measurements on the meters are indicated on the diagram.
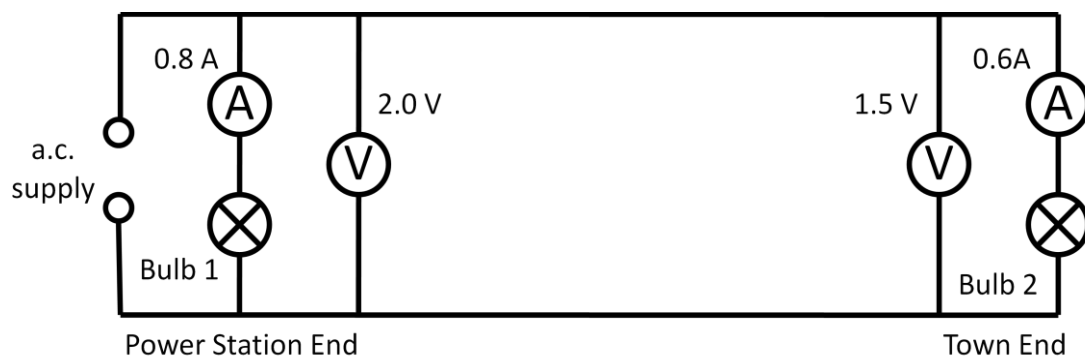
    (a) Calculate the power produced at (i) bulb 1 and (ii) bulb 2.
    (b) Using your answers to part (a), calculate the power loss in the transmission line.
    (c) Draw a circuit diagram of a model power line which has been altered to reduce the power loss, allowing it to transfer more electrical power.
    (d) Explain any additions that you have made.

8. Electricity can be transmitted using (a) overhead power lines or (b) cables buried beneath the ground. Describe a situation where option (a) and option (b) would be the best solution.

9. Give three advantages and disadvantages of overhead power cables versus underground cables.

10. What is meant by the term **'microgeneration'** and what advantage might it have over electricity obtained from the National Grid?

Efficiency

1. What is the efficiency of a biomass power station which has a thermal capacity of 35 MW and generates 10 MW of electrical power?

2. A wind turbine generator which is 95% efficient uses 3.0 MJ of wind energy. What is its energy output?

3. A wave farm is 80% efficient has an electrical output power of 30 MW. What is the input power of the waves?

4. A small scale combined heat and power biomass power plant produces 7.5 MW of electrical power and 24.0 MW of thermal power from a boiler rated at 35 MW. Calculate (a) the electrical efficiency, (b) the thermal efficiency and (c) the overall efficiency of the power plant.

5. In the Arizona desert, solar energy reaches the Earth's surface at a rate of 2000 joules per second on each square metre.
   (a) If an area of desert measuring 30 m x 50 m was completely covered in solar cells, what is the maximum power output that could be obtained?
   (b) If the solar cells are 20% efficient, what would be the actual electrical power output?
   (c) Why would the same area of solar cells produce less electricity in Scotland?

6. A transformer connected to the mains supply has an input power of 2 W.
   (a) If the transformer is 90% efficient, what is the output power?
   (b) If the output voltage is 6 V, what is the output current?

7. A transformer is connected to 230 V mains electricity. The primary coil has 400 turns and the secondary coil has 50 turns.
   (a) Calculate the output voltage of the transformer.
   (b) If the input current is 0.5 A and the output current is 3.5 A, calculate the efficiency of the transformer.

8. In a model hydroelectric power station, a mass of 500 g of water falls through a height of 1.5 metres in 5 seconds into a water turbine and electrical generator. During this time, the output current is 250 mA and the output voltage is 2 V.
   (a) Calculate the power input to the generator.
   (b) Calculate the power output of the generator.
   (c) Calculate the efficiency of the generator?
   (d) What is the main form of energy loss?

9. At a small hydroelectric power station, every minute 300,000 kg of water falls through a vertical height of 48 m from the reservoir to the water turbines below.
   (a) Calculate the mass of water falling each second.
   (b) Calculate the power input to the power station.
   (c) If the power station is 85% efficient, what is the electrical power output?

10. A biomass power station burns wood chips at a rate of 14400 tonnes per hour to produce electricity.   One ton of wood chips releases 1.4 KJ of thermal energy.
    (a) How much thermal energy is produced in the boiler every second?
    (b) If the power plant is 40% efficient, how much electrical energy is produced every second?

2.5 Heat

1.   Copy and complete the following sentences using the words provided below:

      joules; temperature; degrees Celsius; energy

      _ _ _ _ _ _ _ _ _ _ _ _ means how hot or cold a substance is.

      Temperature is measured in _ _ _ _ _ _ _ _ _ _ _ _   .

      Heat is a form of _ _ _ _ _ _ _ _ _ _ _ _ .

      All energy is measured in units called _ _ _ _ _ _ _ _ _ _ _ _ .

2.   When the temperature of a substance rises, what happens to the particles of that substance?

3.   Explain what happens to the speed of the particles of a substance that cools down.

4.   The heat energy required to warm up a substance depends on the material itself and the temperature rise.   Name one other factor upon which the heat energy depends.

5.   In the formula $E = cm \Delta T$, what do the symbols E, c, m and ΔT stand for and in what units are they measured?

Specific Heat Capacity

1.   Write down the definition of specific heat capacity.

2.   Calculate how much energy is required to heat a 20 kg block of copper from 20 °C to 45 °C (c for copper is 400 J/kg°C).

3.   A 40 kg lump of steel cools down from 55 °C to 20 °C.   How much heat energy is given out?   (c for steel is 500 J/kg°C).

4.   The specific heat capacity of water is 4200 J/kg°C.   Calculate:
      (a) The amount of heat energy needed to raise the temperature of 2 kg of water by 10 °C.
      (b) The heat energy given out when 1.5 kg of water cools down from 80 °C to 20 °C.
      (c) The mass of water present if 16,800 J of energy produces a temperature rise of 20 °C.

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

6.   During a heat experiment, a pupil supplies 20 kJ of energy from a heater to 250 g of water in a plastic cup (c for water is 4200 J/kg°C).
      (a) Calculate the increase in temperature of the water.
      (b) The pupil discovers that the actual increase in temperature of the water is only 14 °C.   Account for the difference in your answer to (a)

(c) She now gives 20 KJ of heat to 250 g of methylated spirits (c = 2500 J/kg°C). Calculate the temperature rise.

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

8. 1.344 MJ of heat energy are used to heat water from 20 °C to 100 °C. Calculate the mass of water if the specific heat capacity of water is 4200 J/kg°C.

9. 9600 J of heat energy is supplied to 1 kg of methylated spirit in a polystyrene cup.
    Calculate the rise in temperature produced.
    Take the specific heat capacity of methylated spirit to be 2300 J/kg°C.

10. When 2.0×10^4 J of heat is supplied to 4 kg of paraffin at 10 °C in a container the temperature increases to 14 °C.
    (a) Calculate the specific heat capacity of the paraffin.
    (b) Explain why the result in part a) is different from the theoretical value of 2200 J/kg°C.

11. If a kettle containing 2 kg of water cools from 40 °C to 25 °C, calculate the heat given out by the water. The specific heat capacity of water is 4200 J/kg°C

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

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

14. The specific heat capacity of Fireclay is 800 J/kg°C.
    (a) How much energy can be stored in a night storage heater containing 60 kg of Fireclay, if it is heated up by 100 °C.
    (b) If the heater takes 4 hours to heat up, and the heating element works at 230 volts, what is the value of the current that flows through the element?

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

2.6 C
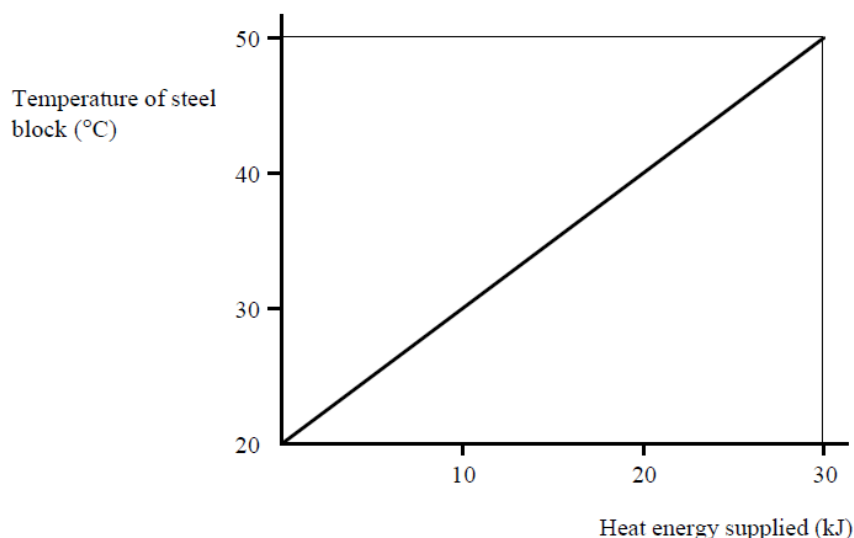
1. If 200 g of water at 40 °C are mixed with 100 g of water at 10 °C and no energy is lost, what is the final temperature of the mixture?
    (Specific heat capacity of water = 4200 J/kg°C)

2. If an immersion heater heats 300 g of water for 2 minutes and the temperature rises by 30 °C, find the power rating of the heater in watts.
    (Specific heat capacity of water = 4200 J/kg°C)

3. A 350 W element is used to boil 300 g of water in a cup. The initial temperature of the water is 20 °C
    (Specific heat capacity of water = 4200 J/kg°C).
    a) How long will it take to reach 100 °C?
    b) State any assumptions made.

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

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

6. A pupil put 2 litres of water at 20 °C into her 1000 W kettle and switched it on.   After 10 mins, she switched it off again.   1 litre of water has a mass of 1 kg.
    a) How much electrical energy has been used?
    b) Did the water in the kettle boil?

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

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

9. One type of exercise machine is shown below.
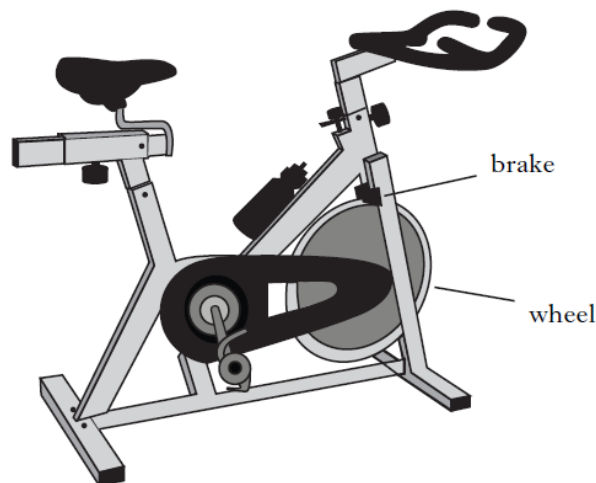
(*a*) A person using   this machine pedals against   friction forces applied to the wheel   by the brake.
    A friction force of 300N is applied at the edge of the wheel, which has a circumference of 1.5m.
    (i)   How much work is done by friction in one turn of the wheel?
    (ii) The person turns the wheel 500 times in 5 minutes.   Calculate the average power produced.
(*b*) The wheel is a solid aluminium disc of mass 12.0 kg.
    (i) All the work done by friction is converted to heat in the disc.   Calculate the temperature rise after 500 turns (Specific heat capacity of aluminium is 902 J/kg).

(ii) Explain why the actual temperature rise of the disc is less than calculated in (*b*) (i).

10. A student reproduces Galilleo's famous experiment by dropping a solid copper ball
of mass 0·50 kg from a balcony on the Leaning Tower of Pisa.
(Specific heat capacity of copper = 380 J/kg°C).
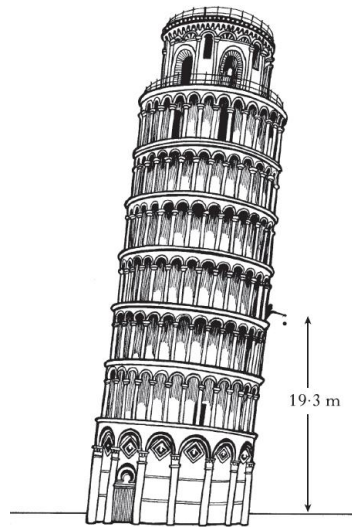
19·3 m

(i) The ball is released from a height of 19·3 m.
Calculate the gravitational potential energy lost by the ball.
(ii) Assuming that all of this gravitational potential energy is converted into heat energy **in the ball**,
calculate the increase in the temperature of the ball on impact with the ground.
(iii) Is the actual temperature change of the ball greater than, the same as or less than the value
calculated in part (*a*)(ii)? You **must** explain your answer.

Generation of Electricity and Heat

Answers

Renewable and non-renewable fuels

1. Fossil fuels.
2. Fossil fuels are made from the remains of plants and tiny animals that lived millions of years ago.
3. Coal, oil and gas.
4. They consist of mainly hydrocarbons which release large amounts of energy when burned.
5. They will eventually run out.
6. They cause acid rain and contribute to global warming.
7. Uranium and peat.
8. Solar, wind, waves, tidal, geothermal, hydroelectric and biomass.
   See summary notes for a description of how they produce electricity.
9. See summary booklet for a list of advantages and disadvantages
10. (a) 1Gigawatt = 1 billion Watts = 1000 Megawatts = 1,000,000,000 Watts
    (b) Wind = 5 Gw; Waves = 3.5 Gw; Solar = 1.5 GW
11. (a) 2500 kW
    (b) 625 kW
    (c) 800 m
12. (a) It is windy and has the highest power available per square metre
   (b) 1,680,000 w or 1.68 MW

Transformers
1. A transformer is a device that can change the voltage and current in an a.c. circuit.
2. Input coil, iron core, output coil
3. (a) An alternating voltage in the primary coil creates a changing magnetic field in the iron core. This
   changing magnetic field then induces an alternating voltage of the same frequency in the secondary coil.

(b) Increase the size of the voltage, current and number of turns on the coil in the input circuit.
4. Television set, computer hard drive, mobile phone charger
5. Only an alternating voltage will give a constantly changing magnetic field.
6. $V_S/V_P = N_S/N_P$
7. 30 V, 300 V, 25 V,
    25 turns, 20 turns, 480 turns,
    10 turns, 400 turns, 500 turns,
    120 V, 10 V, 110 V
8. 24 V, 10 V, 115 V, 500 V, 240 turns, 1000 turns.
9. An ideal transformer is assumed to be 100% efficient.
10. Heat loss in the coils, losses due to magnetisation and demagnetisation of the core, sound losses due to vibration of the coil and losses due to eddy currents and circular currents induced in the core.

Transmission of electricity
1. (a) A network of cables used to transport electricity around the country.
    (b) To reduce energy losses due to resistance heating in the cables.
2. 1: power station – to generate electricity.
    2: transformer – to step up voltage for transmission in power lines.
    3: National grid – system of power lines & cables to carry electrical energy around the country.
    4: Transformer – to step-down the voltage for use in factories and homes.
    5: Underground cables - to carry electrical energy in built up areas.
3. 353 turns.
4. The primary : secondary turns ratio is 48 : 1
5. (a) 2.52 w (b) 1.7 A (c) 20 Ω
6. (a) 20 kw) (b) 0.02 w
7. (a) (i) 1.6 w (ii) 0.9 w
    (b) 0.7 w
    (a)
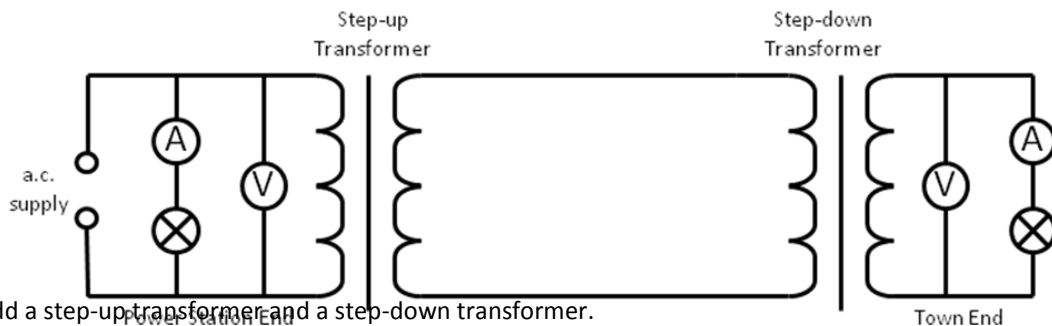
    (d) Add a step-up transformer and a step-down transformer.
8. (a) Transporting electricity across country.
    (b) Transporting electricity in built up areas or areas of natural beauty.
9. Overhead power lines are less expensive to install and maintain than underground cables.
    The large pylons that carry overhead power lines are considered unattractive, while underground cables have less visual impact on the environment.
    Overhead power lines are more vulnerable to severe bad weather than underground cables.
    The expected lifetime of overhead power lines is roughly twice that of underground cables.
10. Microgeneration is the small-scale generation of electricity by individuals and small communities to meet their own needs and is viewed by some as a more environmentally friendly alternative to obtaining electrical power through the National Grid.

Efficiency
1. 28.6%
2. 2.85 J
3. 37.5 MW
4. (a) 21.4% (b) 68.6% (c) 90 %
5. (a) 3 MW (b) 0.6 MW (c) Less sunny in Scotland
6. (a) 1.8 W (b) 0.3 A

7. (a) 1.5 W (b) 87.5%
8. (a) 1.5 W (b) 0.5 W (c) 33.3 % (d) heat and Sound
9. (a) 5,000 Kg (b0 240,000 W (c) 204,000 W
10. (a) 5.6 kJ (b) 2.24 kJ

Heat and Temperature
1. Temperature; Degrees Celsius; Energy; Joules
2. The particles move around faster.
3. The particles slow down
4. Mass
5. E = heat transferred in Joules
    c = specific heat capacity in J/kg°C
    m = mass of material in kg
    ΔT = change in temperature in °C

Specific Heat Capacity
1. The specific heat capacity of a substance is defined as the amount of heat energy required to change the temperature of 1 kg of a substance by 1 °C.
2. 200,000 J
3. 700,000 J
4. (a) 84,000 J (b) 378,000 J (c) 0.2 kg
5. 20000 J
6. (a) 19.05 °C (b) heat lost to the surroundings (c) 32 °C
7. 4 MJ
8. 4 kg
9. 4.17 °C
10. (a) 1250 J/kg°C (b) The difference is due to heat lost to the surroundings
11. 126,000 J
12. 105 J/kg°C
13. 4560 J
14. (a) 4.8 MJ (b) 1.45 A
15. 500 J/kg°C

Conservation of energy
1. 30 °C
2. 315 W
3. (a) 288 s (b) No heat is lost to the surroundings
4. 6000 J/kg°C
5. (a) 450,000 J
b) 21.4 °C
6. (a) 600,000 J (b) No
7. 45,000 J/kg°C
8. 76 m
9. (a) (i) 450 J (ii) 750 W
    (b) (i) 20.8 °C (ii) heat is lost to the surrounding air
10. (i) 96.5 J (ii) 0.5 °C (iii) The actual temperature change is less as heat is lost to the surroundings

2.7 Gas laws and The Kinetic Model   National 4

1. What are the three states of matter?

2. For each of the three states of mater describe how the particles are arranged and how they move.

3.

(a) Explain in terms of kinetic theory the effect on the pressure of the gas when the piston is removed and the gases' volume increases, while its temperature remains constant.
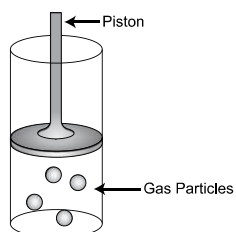
(b) Explain in terms of kinetic theory the effect on the pressure of the gas when the temperature of the gas increases, while its volume remains constant.
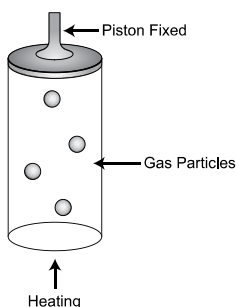
(c) Explain in terms of kinetic theory the effect on the pressure and volume of the gas when the temperature increases.
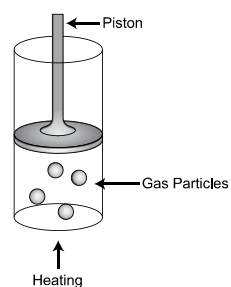
4. For each situation in Q3 (a), (b) and (c) describe a practical application.

Gas laws and The Kinetic Model   National 5

Pressure

1. What is meant by the term pressure?

2. What are the units of pressure?

3. State the equation that elates pressure, force and area.

4. A box weighs 120 N and has a base area of 2 m². What pressure does it exert on the ground?

5. A bag weighs 30 N and has a base area of 0.5 m². what pressure does it exert on the ground?

6. A suitcase has a weight of 400 N and has dimensions 0.3m by 1.5 m.

   (a) What is the area of the suitcase?

   (b) What pressure does it exert on the floor?

7. A girl has a mass of 45 kg. Her foot has dimensions 0.2 m by 0.1 m.
   (a) What pressure does she exert with her foot on the ground?
   (b) What pressure would she exert with her two feet on the ground?

8. Shown in the diagram are Eskimos wearing the special shoes they use to walk in deep snow.
   Explain why they wear these.

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9. Explain why the use of large tyres helps to prevent tractors from sinking into soft ground.

Gas laws

Pressure and volume (constant temperature)

1. 100 cm^3 of air is contained in a syringe at atmospheric pressure (1 x 10^5 Pa). If the volume is reduced to a) 50 cm^3 or b) 20 cm^3 without a change in temperature, what will be the new pressures ?

2. If the piston in a cylinder containing 300 cm^3 of gas at a pressure of 10^5 Pa is moved outwards so that the pressure of the gas falls to 8×10^4 Pa, find the new volume of the gas.

3. A weather balloon contains 80 m^3 of helium at normal atmospheric pressure of 1 x 10^5 Pa. What will be the volume of the balloon at an altitude where air pressure is 8×10^4 Pa?

4. The cork in a pop-gun is fired when the pressure reaches 3 atmospheres. If the plunger is 60 cm from the cork when the air in the barrel is at atmospheric pressure,

how far will the plunger have to move before the cork pops out?

60 cm
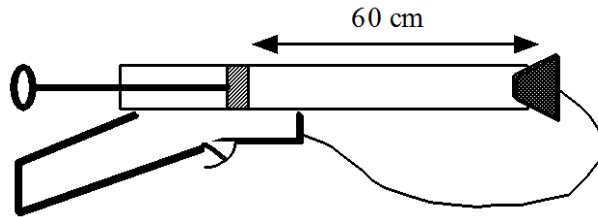
5. A swimmer underwater uses a cylinder of compressed air which holds 15 litres of air at a pressure of 12000 kPa.
   (a) Calculate the volume this air would occupy at a depth where the pressure is 200 kPa.
   (b) If the swimmer breathes 25 litres of air each minute at this pressure, calculate how long the swimmer could remain at this depth (assume all the air from the cylinder is available).

Pressure and temperature (constant volume)

1. Convert the following celsius temperatures to kelvin.
   a) -273 °C   b) -150 °C   c) 0 °C   d) 27 °C   e) 150 °C

2. *Convert the following kelvin temperatures to celsius.*
   a) 10 K   b) 23 K   c   ) 100 K   d) 350 K   e) 373 K

3. A cylinder of oxygen at 27 °C has a pressure of 3×10^6 Pa. What will be the new pressure if the gas is cooled to 0 °C?

4. An electric light bulb is designed so that the pressure of the inert gas inside it is 100 kPa (normal air pressure) when the temperature of the bulb is 350 °C. At what pressure must the bulb be filled if this is done at 15 °C ?

5. The pressure in a car tyre is 2.5×10^5 Pa at 27 °C. After a long journey the pressure has risen to 3.0×10^5 Pa. Assuming the volume has not changed, what is the new temperature of the tyre?

6. A compressed air tank which at room temperature of 27 °C normally contains air at 4 atmospheres, is fitted with a safety valve which operates at 10 atmospheres.

   During a fire the safety valve was released. Estimate the average temperature of the air

in the tank when this happened.

7.   (a) Describe an experiment to find the relationship between the pressure and
            temperature of a fixed mass of gas at constant volume. Your answer should
            include:
            (i)   a labelled diagram of the apparatus
            (ii) a description of how you would use the apparatus
            (iii) the measurements you would take.

       (b) Use the following results to plot a graph of pressure against temperature in °C
            using axes as shown below.

Pressure / kPa	91	98	104	110	117
Temperature / ° C	0	20	40	60	80

p / kPa

-300   0   100   T / ° C
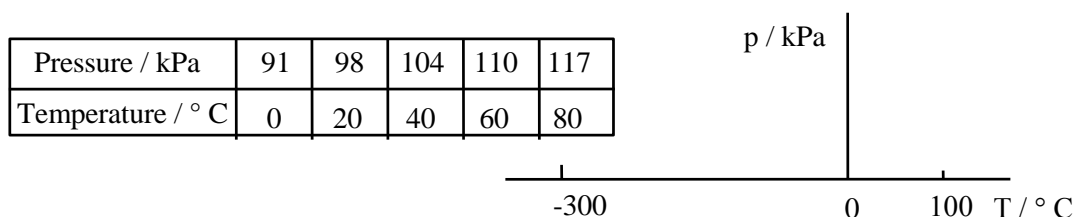
            (i)   Explain why the graph you have drawn shows that pressure does not vary
                  directly as celsius temperature.
            (ii) Explain how the graph can be used to show direct variation between
                  temperature and pressure if a new temperature scale is introduced.
            (iii) **Use the graph** to estimate the value in °C of the zero on this new temperature
                  scale.
       (c) Use the particle model of a gas to explain the following:
            (i)   why the pressure of a fixed volume of gas decreases as its temperature
                  decreases
            (ii) why the pressure of a gas at a fixed temperature decreases if its volume
                  increases
            (iii) what happens to the molecules of a gas when Absolute Zero is reached.

Volume and temperature (constant pressure)

1. Describe an experiment to find the relationship between the volume and temperature of
   a fixed mass of gas at constant pressure. Your description should include:
       (a) a diagram of the apparatus used
       (b) a note of the results taken
       (c) an appropriate method to find the relationship using the results.

  2. 100 cm^3 of a fixed mass of air is at a temperature of 0 °C. At what temperature will the

volume be 110 cm^3 if its pressure remains constant.

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

4. The volume of a fixed mass of gas at constant temperature is found to be 50 cm^3. The pressure remains constant and the temperature doubles from 20 °C to 40 °C. Explain why the new volume of gas is not 100 cm3.

General gas equation

1. *Given, for a fixed mass of gas, p } T and p } 1/V, derive the general gas equation.*

2. Find the unknown quantity from the readings shown below for a fixed mass of gas.

(a) $p_1 = 2 \times 10^5$ Pa $V_1 = 50$ cm^3 $T_1 = 20$ °C
     $p_2 = 3 \times 10^5$ Pa $V_2 = ?$ $T_2 = 80$ °C

(b) $p_1 = 1 \times 10^5$ Pa $V_1 = 75$ cm^3 $T_1 = 20$ °C
     $p_2 = 2.5 \times 10^5$ Pa $V_2 = 100$ cm^3 $T_2 = ?$

(c) $p_1 = 2 \times 105$ Pa $V_1 = 60$ cm^3 $T_1 = 20$ °C
     $p_2 = ?$ $V_2 = 80$ cm^3 $T_2 = 150$ °C

d) $p_1 = 1 \times 10^5$ Pa $V_1 = 75$ cm^3 $T_1 = ?$
     $p_2 = 2.5 \times 10^5$ Pa $V_2 = 50$ cm^3 $T_2 = 40$ °C

3. A sealed syringe contains 100 cm^3 of air at atmospheric pressure 10^5 Pa and a temperature of 27 °C. When the piston is depressed the volume of air is reduced to 20 cm^3 and this produces a temperature rise of 4 °C. Calculate the new pressure of the gas.

4. Calculate the effect the following changes have on the pressure of a fixed mass of gas.

   (a) Its temperature (in K) doubles and volume halves.
   (b) Its temperature (in K) halves and volume halves.
   (c) Its temperature (in K) trebles and volume quarters.

5. Calculate the effect the following changes have on the volume of a fixed mass of gas.

   (a) Its temperature (in K) doubles and pressure halves.
   (b) Its temperature (in K) halves and pressure halves.
   (c) Its temperature (in K) trebles and pressure quarters.

6. Explain the pressure-volume, pressure-temperature and volume-temperature laws qualitatively in terms of the kinetic model.

Gas Laws and The Kinetic Model   Answers   National 4

1. solid, liquid and gas
2. solid - particles are very close together and vibrate.
   liquid - particles are close together and swap places with their nearest neighbours.
   gas - particles are far apart and move very fast in random directions.
3. (a) as the volume that the gas occupies increases the pressure of the gas decreases.
   (b) when the temperature is increased the particles gain more kinetic energy and move around faster - this increases it pressure.
   (c) when the temperature increases and the piston is free to move; the kinetic energy increases, the speed of the particles increases, the pressure of the gas on the piston increases therefore the force on the piston increases and forces it upwards, causing the volume to increase.
4. (a) divers in water / fish in the sea
   (b) tyres bursting in summer
   (c) football inflated then deflating in the cold.

Pressure   Answers   National 5
1. pressure is force per unit area
2. Pascal's : N/m^2 or Nm^{-2}
3. $P = F/A$
4. 60 N/m^2
5. 60 N/m^2
6. (a) 0.45 m^2
   (b) 889 N/m^2
7. (a) 0.02 m^2 22500 N/m^2
   (b) 11250 N/m^2
8. Making the surface area of their feet bigger decreases the pressure of their bodies into the snow. therefore they don't sink in as much since $P = F/A$
9. Larger tyres, greater surface area, since $P = F/A$ the pressure on the ground is reduced.

Gas Laws

Pressure and Volume

1. (a) $2 \times 10^5 \text{ Pa}$ (b) $5 \times 10^5 \text{ Pa}$

2. 375cm^3
3. 100 cm^3
4. 20 cm^3
5. (a) 900 litres   (b) 36 minutes

Pressure and Temperature

1. (a) 0 K   (b) 123 K   (c) 273 K   (d) 300K   (e) 423K
2. (a) -263˚C   (b) -250˚C   (c) -173˚C   (d) 77 ˚C   (e) 100˚C
3. 2.73×10^6 Pa
4. 0.5×10^5 Pa
5. 360 K, 87 ˚C
6. 750 K, 477˚C

7. (a) (i) See summary notes page 52
       (ii) as the temperature of the gas is increased measure the pressure of the gas using the pressure sensor.
       (iii) read the temperature from the thermometer, read the pressure from the pressure sensor.
   (b)
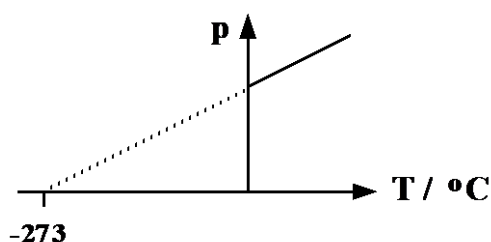
   (i) since the line does not pass through the origin.
   (ii) change ˚C values of temperature into kelvins by adding 273 to each value.
       plot a graph of pressure against temperature in kelvins; this should produce a straight line through the origin.
   (iii) ~ 273˚C

   (c) (i) temeperature decrese causes the particles to loss kinetic energy and velocity, less force on the walls of the container and less number of collisions - pressure is reduced according to P = F/A.
       (ii) at absolute zero all particle movement stops.

Volume and Temperature

1. See summary notes page 54
2. 300.3 K   27˚C

3. 0.12 cm^3
4. 53.4 cm^3, since the temperature increases the volume decreases, showing that volume is inversely proportional to temperature in kelvins.

General Gas Equation

1. P α 1/ V   P x V = constant

   P α T (kelvins) $\dfrac{P}{T}$ = constant

   therefore $\dfrac{P \times V}{T}$ = constant

2. (a) 40 cm^3 (b) 1054.8 K   782˚C   (c) 2.2 x 10^5 Pa

   (d) 187.8 K   -85˚C

3. 5.07 x 10^5 Pa

4. (a) pressure x 4   (b) pressure stays the same   (c) pressure x 12

5. (a) volume x 4   (b) volume stays the same   (c) volume x 12

6. See summary notes page 56

2.8