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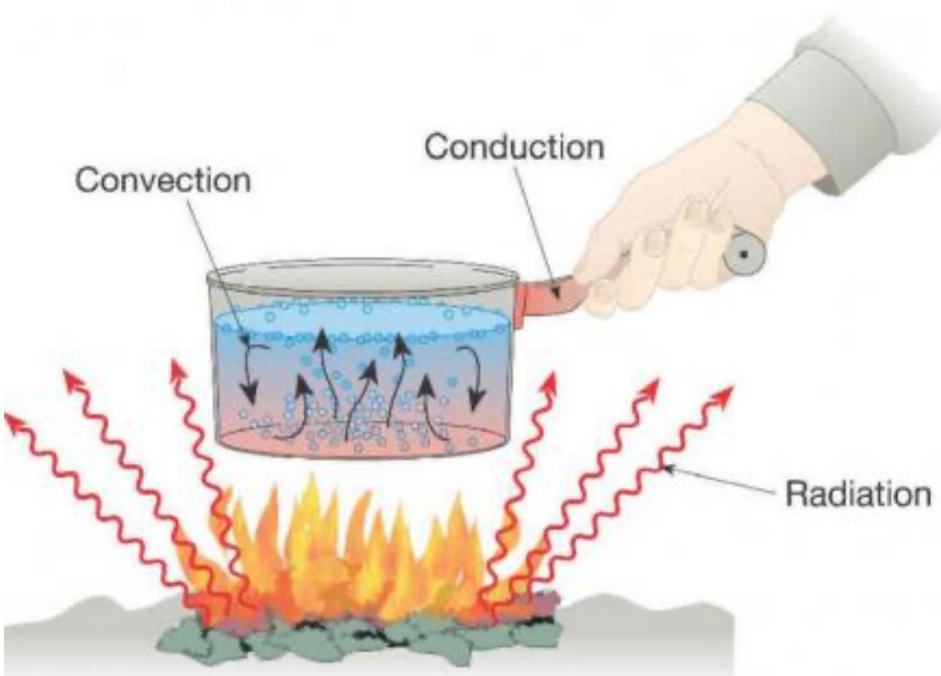
IGCSE Physics



Unit 2 – Energy and Energy Resources

Name: ....

Class: ....

Summary

Energy is a fundamental concept in physics. It is the ability to do work, which in physical terms is the product of a force applied over a distance. It comes in many forms and can be transformed ("transfered") from one form to another. It is this transfer that makes things happen. e.g. a battery connected to a bulb has the energy transfers: chemical potential energy → electrical energy → light + heat energy. We look at the three methods by which heat energy is transferred; conduction, convection and radiation. Finally, and most importantly, we investigate how electrical energy is generated, the nature of fossil fuels and effects of burning them, and different methods of utilising renewable energy resources.

Lesson	Objectives : Students will be assessed on their ability to
Energy Transfer	• describe energy transfers involving the following forms of energy: thermal (heat), light, electrical, sound, kinetic, chemical, nuclear and potential (elastic and gravitational), • understand that energy is conserved and know and use the *relationship: efficiency = useful energy output / total energy output*. • draw energy flow (sankey) diagrams for a variety of everyday and scientific situations.
Heat Transfer	• describe how energy transfer may take place by conduction, convection and radiation. • explain the role of convection in everyday phenomena. • explain how insulation is used to reduce energy transfers from buildings and the human body.
Work	• understand that 'work done' is equal to energy transferred • know and use the formula *Work done = Force × Distance*
Kinetic Energy	• know that kinetic energy is a measure of the amount of energy of a moving object • know and use the relationship $KE = \frac{1}{2} m v^2$
Potential Energy	• understand that Gravitational potential energy is the amount of energy of an object due to its height above the ground. • know and use the relationship $GPE = m g h$
Power	• describe power as the rate of transfer of energy or the rate of doing work • understand how conservation of energy produces a link between gravitational potential energy, kinetic energy and work • use the relationship *Power = Work done / time*
Energy Resources	• describe the advantages and disadvantages of methods of large-scale electricity production using a variety of renewable and non-renewable resources • describe the energy transfer chains illustrating the environmental implications of fossil fuels

Important information

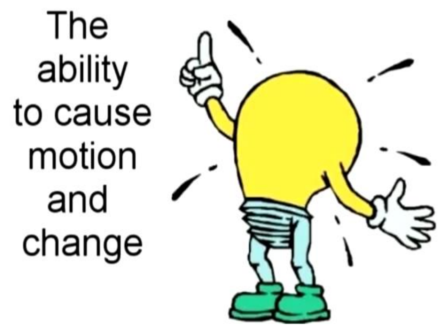
The idea behind this booklet is to keep all your notes and revision material for this topic in one ordered place – and avoid 'lost' worksheets etc. It is expected that you make additional notes and aide memoires wherever you can, as would be the case at college. The booklets will be collected on a weekly basis (depending on the timetable) and certain aspects will be graded. The quality of the overall notes will also be assessed at appropriate intervals. There is a lot of material here and not all of it will be set to all students. Of course, if you wish to do more than this, you are certainly encouraged to do so – and this will be reflected in the grade achieved.

Homework will be set separately to this booklet.

There are other resources available online via my www.isalndphysics.com website. Any additional resources that students may discover, could be included on the site.

PW – Nov 2022

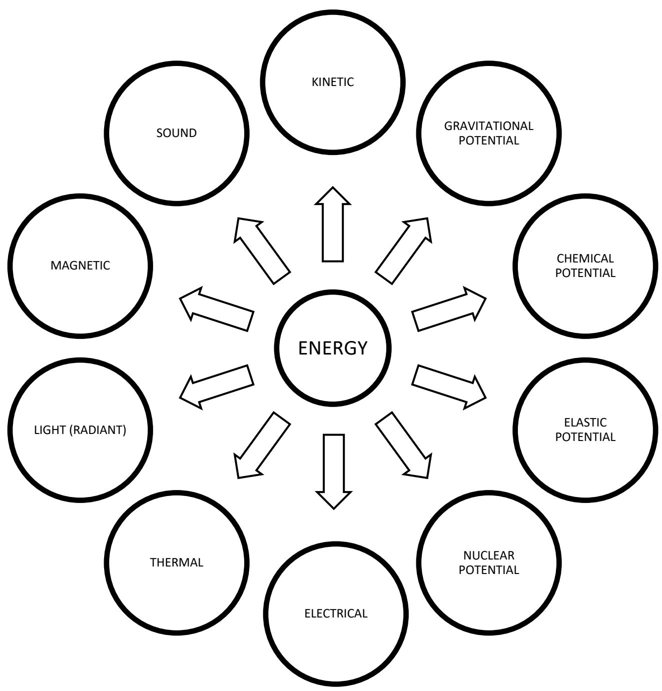
Key Concepts and Equations

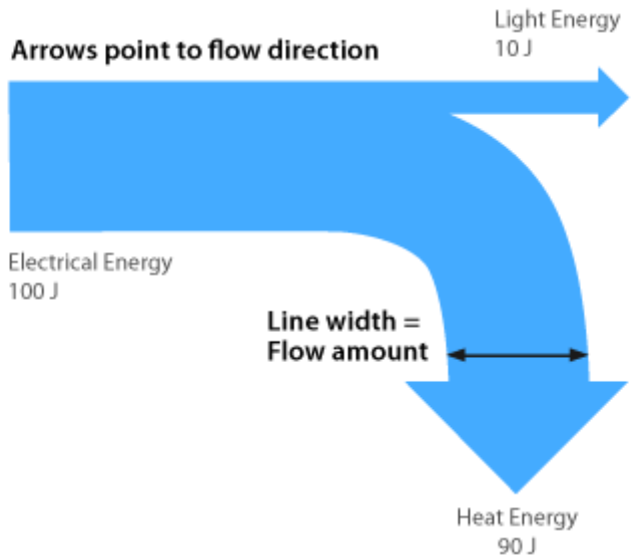


1 – Energy Transfer

Objectives:

- describe energy transfers involving the following forms of energy: thermal (heat), light, electrical, sound, kinetic, chemical, nuclear and potential (elastic and gravitational),
- understand that energy is conserved and know and use the relationship: efficiency = useful energy output / total energy output.
- draw energy flow (sankey) diagrams for a variety of everyday and scientific situations




Arrows point to flow direction
Light Energy
10 J
Electrical Energy
100 J
Line width =
Flow amount
Heat Energy
90 J

CW 2.1 – Energy Transfer

1. An apple growing on a tree has two forms of stored energy. What are they? (1)

2. Draw a Sankey diagram (similar to the one on page 4) for a more efficient LED light bulb. (2)

3. Complete the energy transfer diagram for a car. (1)

   Chemical energy →

4. Write down the energy transfer diagram for the following:
   a) Photovoltaic solar cell (1)

   b) Downhill skier (1)

   c) Archer loosing off an arrow. (1)

   d) Student running on sport's day. (1)

2 – Heat Transfer

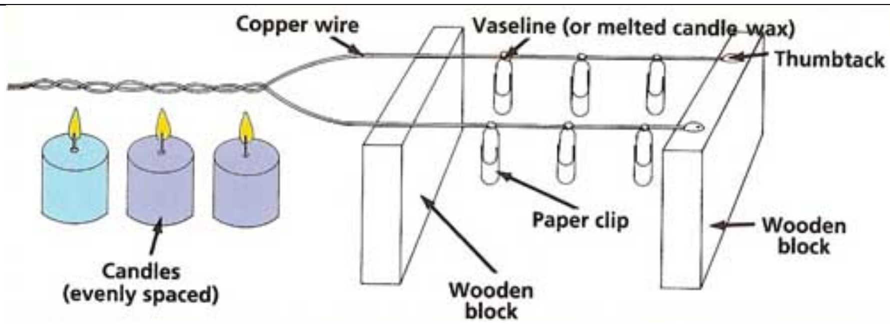
Objectives:

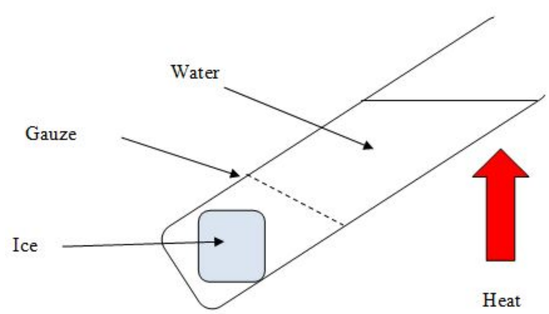
- describe how energy transfer may take place by conduction, convection and radiation.
- explain the role of convection in everyday phenomena.
- explain how insulation is used to reduce energy transfers from buildings and the human body.

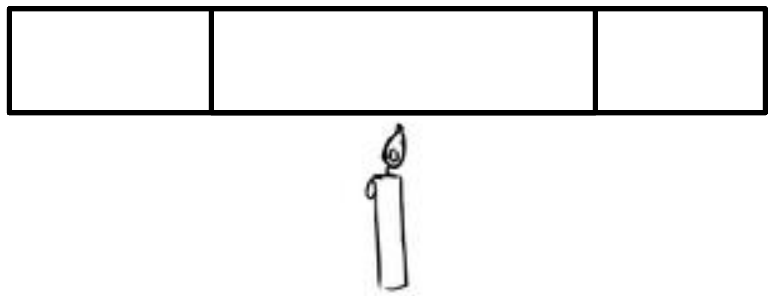
CW 2.2 - Heat Transfer

Aim: To demonstrate the three methods of transfering heat energy

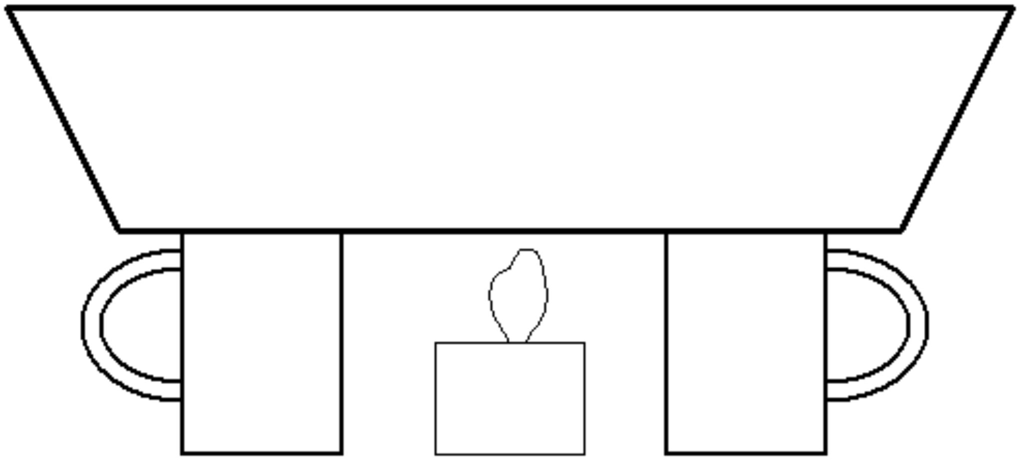
Conduction

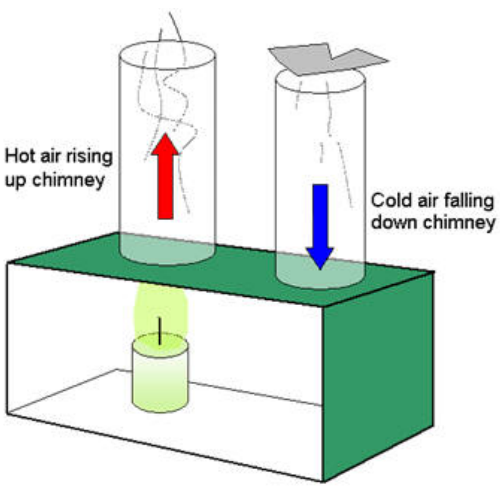


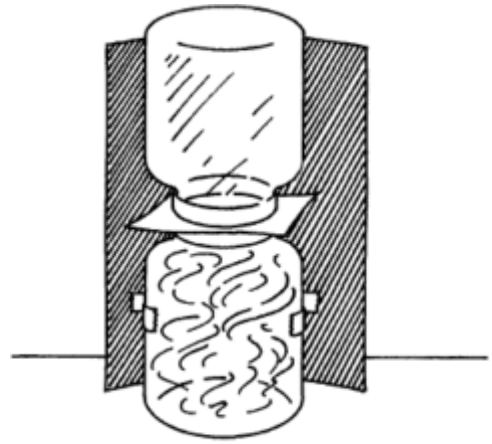


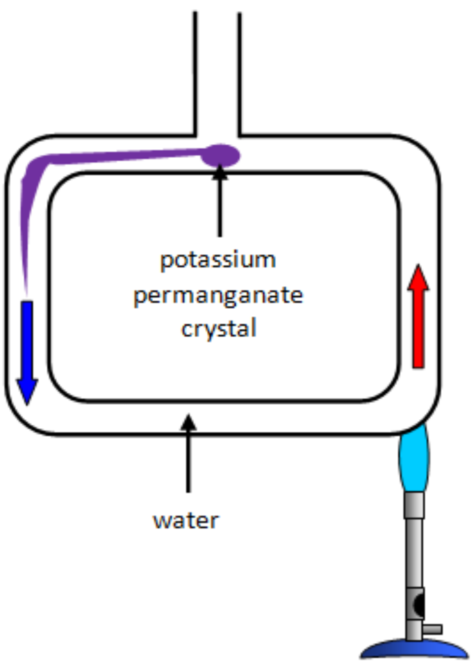


Convection

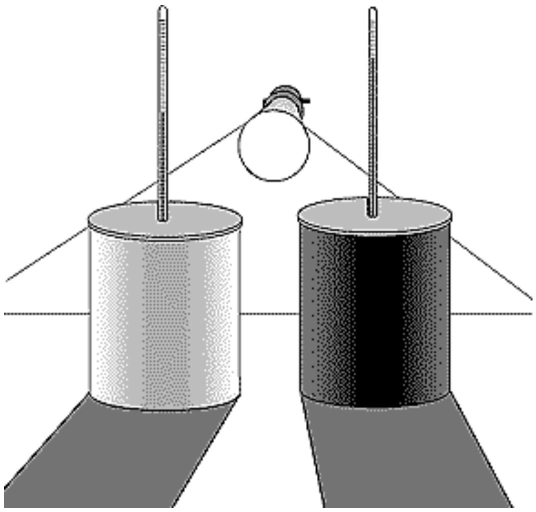







potassium
permanganate
crystal
water

Radiation



CW 2.3 – Thermal Transfer

1. Explain each of the following:

   a) A saucepan might have a copper bottom but a plastic or wooden handle. (1)

   b) Wool and feathers are good insulators. (1)

   c) Metal feels colder than wood even if they are at the same temperature. (1)

   d) The smoke from a fire rises upwards. (1)

   e) The heating element in a kettle is mounted at the bottom. (1)

   f) Covering a water bottle in foil keeps it cooler on the beach. (1)

   g) A black car gets hotter in the summer than a white car. (1)

2. When we exercise there are two cooling systems that come into play in the human body: Our skin becomes redder as the blood vessels close to the skin expand (vasodilation) and we sweat. Explain how these help to cool us down. (2)

3. Dogs don't sweat – so how do they cool down? (1)

4. What features help Bermuda's houses stay cooler in the summer? (Air conditioning doesn't count!) (2)

5. Air conditioning is very expensive. Explain how we can increase the effectiveness of air conditioning at home. (1)

3 – Work

Objectives:

- understand that 'work done' is equal to energy transferred
- know and use the formula *Work done* = *Force* × *Distance*

CW 2.4 - Work Done

1. Which of the following involve **mechanical work**?

   a) A shelf holding up a stack of Physics books.

   b) A hamster moving a treadle wheel.

   c) A footpump being pushed down.

   d) A strong student leaning against a brick wall.

   e) A weightlifter holding 40 kg above her head.

   f) A hotel porter carrying a couple of cases.

   g) The hotel porter holding the cases while waiting for a tip!

2. Calculate the work done in the following situations. Show your calculations.

   a) A stubborn dog being pulled over 5 m of tarmac with a force of 300 N.

   b) A coffee cup of mass 500 g being raised through a height of 40 cm.

   c) A water-skier being pulled over 400 m with a force of 450 N.

   d) A car being pushed 1 km with a force of 1600 N.

3. A weightlifter is working out in a gym. He is using different ‘weights’.

a) He lifts 50 kg 40 times. Each lift raises the load 30 cm. Calculate the work done.

b) He increases the load to 80 kg and completes 10 repetitions.

c) With another machine he raises the load through a height of 65 cm. How much energy does he use doing 15 repetitions of 80 kg?

d) How many lifts of 60 kg over 65 cm would use 10,530 J of energy?

4. A car has broken down just outside Hamilton. There is a garage 2 km away along a flat road.

a) It needs a minimum force of 900 N to push the car along a flat road. What is the minimum amount of energy that the driver needs to get the car to the garage?

b) There is another garage 1.4 km away, but it is up a hill! The pushing force would have to be 1700 N. Calculate the energy required in this case.

c) So….. which is the easiest option?

....

5. The table shows how the force exerted by a sprinter changes with the type of sneaker worn. It also records the distance travelled by the sprinter in 2.0 seconds.

Sneaker	**Force (N)**	**Distance (m)**	**Work done ( )**
Two Stripes	4.2	1.6	
Big Cross	5.6	0.8	
Off Balance	4.8	1.2	
Obverse	5.9	1.4	
High Vest	4.5	0.8	

a) What units should be used for the work column? Complete the table.

b) What force is the work mainly done against?

....

....

4 – Kinetic Energy

Objectives:

- know that kinetic energy is a measure of the amount of energy of a moving object
- know and use the relationship $KE = \frac{1}{2} m v^2$

CW 2.5 - KE

1. A cricket ball has a mass of 200 g (0.2 kg) and is travelling at 20 m/s. Calculate its KE. (2)

2. A tennis ball has a mass of 50 g and is moving at the same speed. Calculate its KE. (2)

3. If the speed of a bike doubles, by what factor does its KE increase by? (2)

4. What is the effect on this on:
   a) Braking distance (1)

   b) Collision impact (1)

5. A watermelon has a mass of 5 kg and has 1000 J of KE. What is its speed? (3)

5 – Potential Energy

text ref: pages 144 - 146

Objectives:

- understand that Gravitational potential energy is the amount of energy of an object due to its height above the ground.
- know and use the relationship $GPE = m\,g\,h$

CW 2.6 - GPE

1. An object has a mass of 6.0 kg What is its GPE if it is:
   a) 4.0 m above the ground? (2)

   b) 8.0 m above the ground? (2)

2. The higher an object from the ground, the greater the GPE it has. What is the implication for the speed of impact? (1) Explain. (1)

3. A tennis ball of mass 58.0 g is dropped from the top of Gibb's Hill lighthouse (obviously don't actually do this!). The lighthouse is 108 m high.
   a) What is the ball's GPE? (2)

   b) What is the ball's KE just before impact with the ground? (1)

   c) Calculate the speed of impact. (3)

   d) Is this result likely to be correct? If not, why not? (2)

6 – Power

Objectives:

- describe power as the rate of transfer of energy or the rate of doing work
- understand how conservation of energy produces a link between gravitational potential energy, kinetic energy and work
- use the relationship *Power* = *Work done* / *time*

LAB: Estimating Personal Power Output

Aim: to use the concepts of work done and power to estimate your personal power output when running up a flight of stairs.

Lab notes:

CW 2.7 – Energy Transfer

1. Electrical kettles are very efficient as about 90% of the electrical energy is transferred into useful heat energy that heats up the water. Car engines are far less efficent, as only about 35% of the stored chemical energy is converted into useful kinetic energy. Of the rest, some 5% is released as sound and the remainder is lost as heat energy to the atmosphere.
   a) Draw Sankey diagrams to show the efficiency of the kettle and the engine.

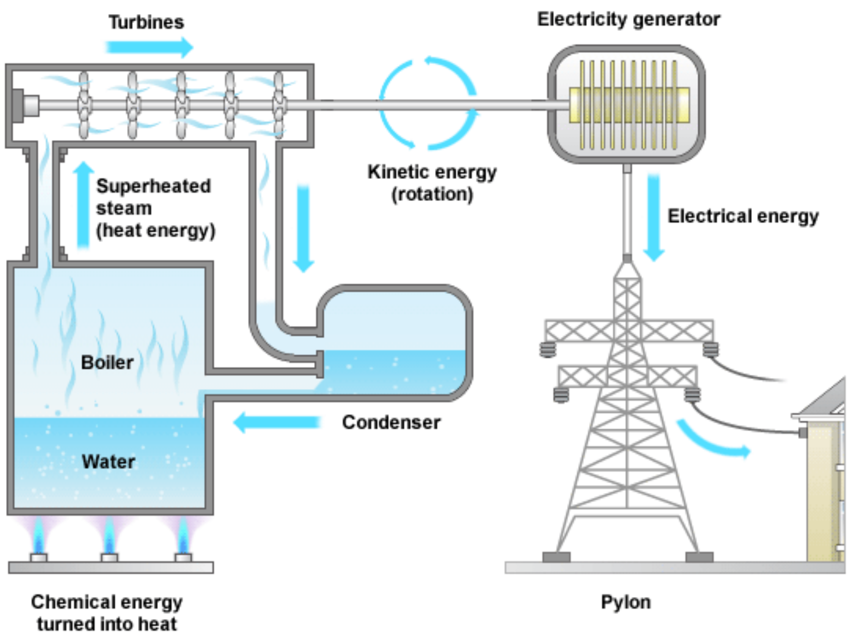
   b) For each of the following devices, suggest what has happened to the missing energy.
      i) Light bulb: electrical → 8% light + …………………………
      ii) Food mixer: electrical → 50% KE + …………………………..
      iii) Transformer: mains electricity → 90% 12V electricity + ………………………..
      iv) Vacuum cleaner: electricity → 70% KE + …………………………

2. Calculate the efficiency for the following:
   a) It takes 500 J of energy to push a box up a ramp. However, the box only gains 300 J of gravitational potentional energy.

   b) It only takes 400 J to roll a barrel up the same ramp giving the same gain in potential energy.

   c) It takes a total energy input of 750 J to lift a 600 N bucket of water by 1 m using a block and tackle.

   d) Why is rolling or lifting a box up more efficient than dragging it?



3. A conventional coal-fired power station loses 9% of its energy when the fuel is first burnt. For every 1 MJ of stored chemical energy in the coal:
   a) How much is lost at this stage?

   b) How much energy remains?

   c) Gas-fired power stations are more efficient at this stage and only lose 5% of the chemical energy stored in the methane. How much energy is 'kept' in this case for every 1 MJ burned?

   d) Of this retained energy, 53% is lost as waste heat up the chimney. What is the remainder of the energy still available to the power station?

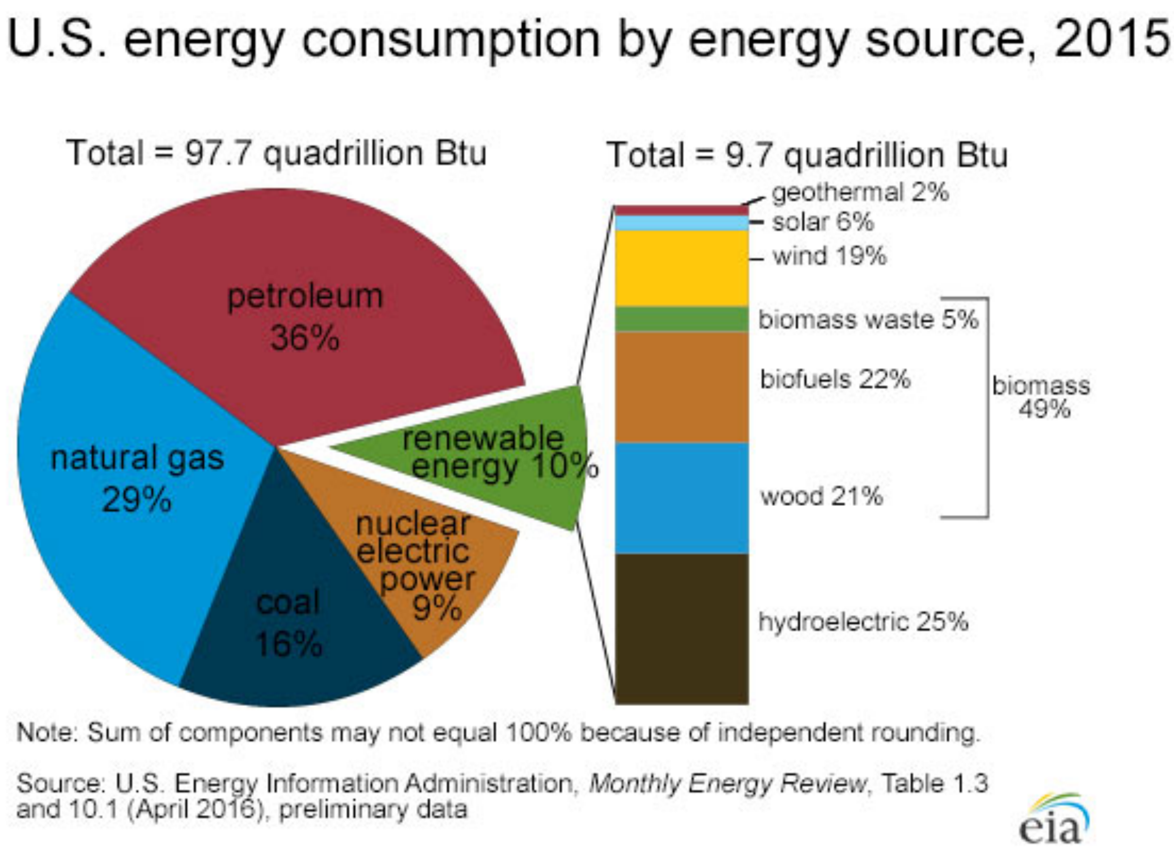
   e) If another 46 kJ is lost in the generator plant, how much electrical energy is produced?

   f) Therefore, what is the overall efficiency of the gas-fired power station?

8 – Energy Resources

Objectives:

- describe the advantages and disadvantages of methods of large-scale electricity production using a variety of renewable and non-renewable resources
- describe the energy transfer chains illustrating the environmental implications of fossil fuels



CW 2.8 - PAST IGCSE QUESTIONS

7 A flying squirrel is an animal that can glide through the air.

It spreads out its limbs to stretch a membrane that helps it to glide.

At the time, students got all in a tizzy because they hadn't studied squirrels! Straightforward question on GPE → KE

© Robert Savannah

(a) The mass of a flying squirrel is 0.19 kg.

It climbs 17 m up a tree.

(i) State the equation linking gravitational potential energy (GPE), mass, *g* and height. **(1)**

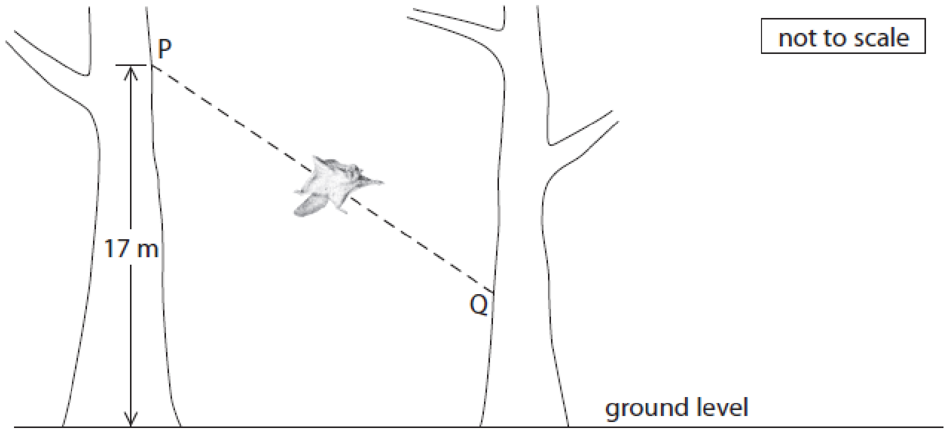
(ii) Calculate the GPE gained by the squirrel during this climb. **(2)**

GPE = ... J

(iii) State the amount of work done against the force of gravity by the squirrel during this climb. **(1)**

work done = ... J

(b) The flying squirrel glides from P to Q with a constant velocity of 13 m/s.



(i) Add labelled arrows to the diagram to show the directions of the forces of weight and drag acting on the squirrel.

(2)

(ii) State the equation linking kinetic energy (KE), mass and velocity.

(1)

(iii) Calculate the KE of the squirrel as it glides.

(2)

KE = ... J

(iv) The velocity of the squirrel decreases to zero when it reaches the second tree because

(1)

☒ **A** an unbalanced force acts on the squirrel

☒ **B** no force acts on the squirrel

☒ **C** the GPE of the squirrel increases

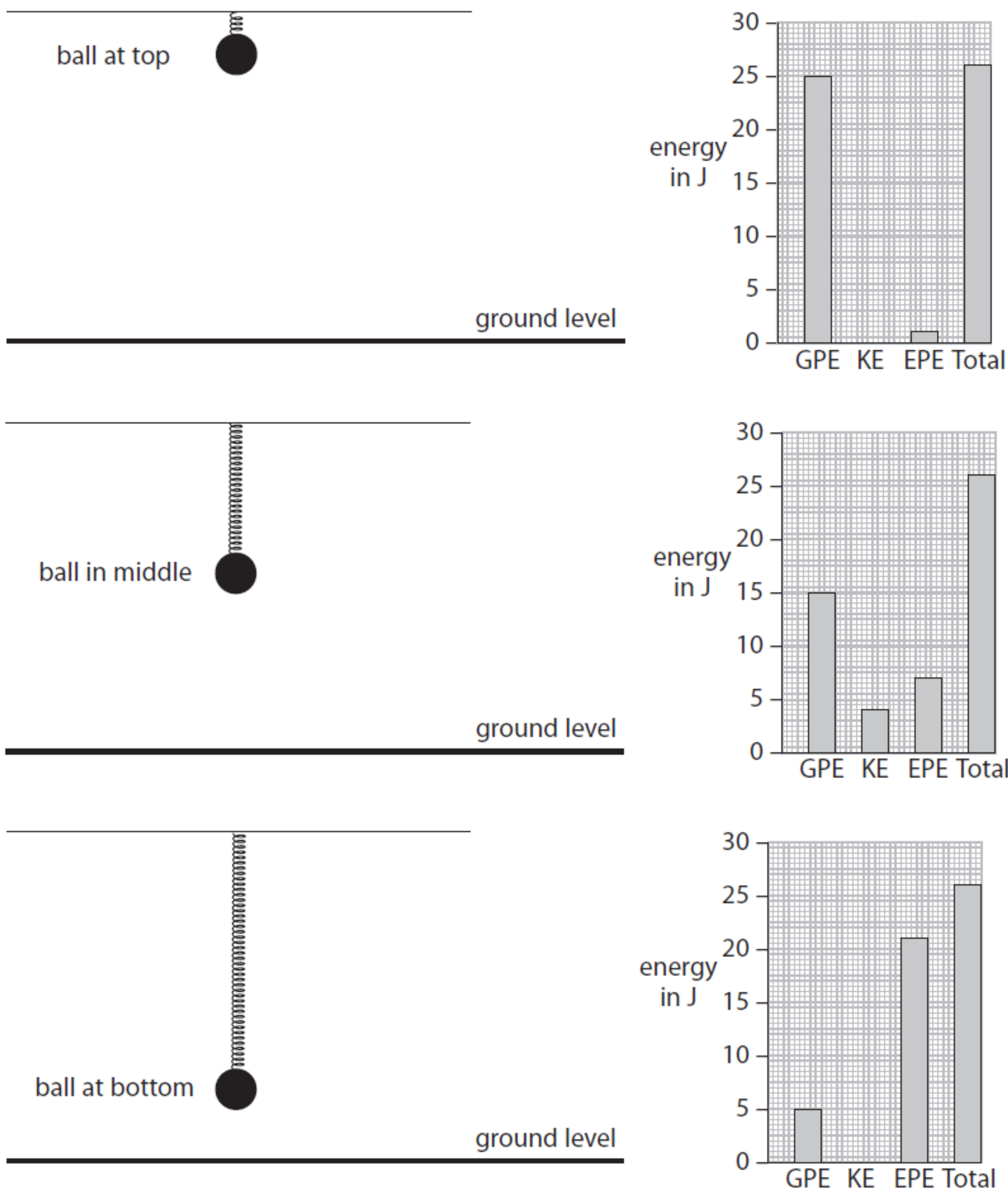
☒ **D** the KE of the squirrel increases

(Total for Question 7 = 10 marks)

11 A student investigates how the energies of a ball and spring change when the ball and spring vibrate together.

The diagrams and bar charts show how the energies of the ball and spring vary with the position of the ball.

The ball has a mass of 1 kg.



GPE = gravitational potential energy of the ball (zero at ground level)

KE = kinetic energy of the ball

EPE = elastic potential energy of the spring

Use information from the diagrams and the bar charts to describe what happens to the energy, speed and position of the ball as it vibrates on the spring.

(6)

(Total for Question 11 = 6 marks)

Challenging question – avoid waffling.

6 marks gives a clue as there are 3 stages in the diagram opposite. Don't just state what is happening to the energy (e.g. GPE decreasing.) But explain **why** it is decreasing.

7 In 2013, the UK Government decided to build another nuclear power station at Hinckley Point. Hinckley Point is in Somerset, a major agricultural area of the UK. This will be the third nuclear power station at the site.

©guardian

Read the question! Students often forget to mention anything about the biomass power stations.

Discuss the advantages and disadvantages of nuclear power stations and biomass power stations.

(6)

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(Total for Question 7 = 6 marks)

(c) In 1971, astronaut Alan Shepard hit a golf ball on the surface of the Moon.

The golf ball had a mass of 50 g and he transferred 56 J of energy to it.

(i) State the equation linking kinetic energy, mass and velocity.

(1)

(ii) Calculate the initial velocity of the ball.

(3)

initial velocity = ... m/s

You should be expert by now at rearranging the KE equation!

(d) At its highest point the ball had gained 12 J of gravitational potential energy.

(i) State the kinetic energy of the ball at its highest point.

(1)

kinetic energy = ... J

(ii) State the equation linking gravitational potential energy, mass, *g* and height.

(1)

(iii) Calculate the maximum height that the ball reached.
(gravitational field strength on the Moon, $g = 1.6$ N/kg)

(2)

maximum height = ... m

(e) Suggest why the ball travelled further on the Moon than it would have done on Earth.

(2)

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(Total for Question 10 = 15 marks)

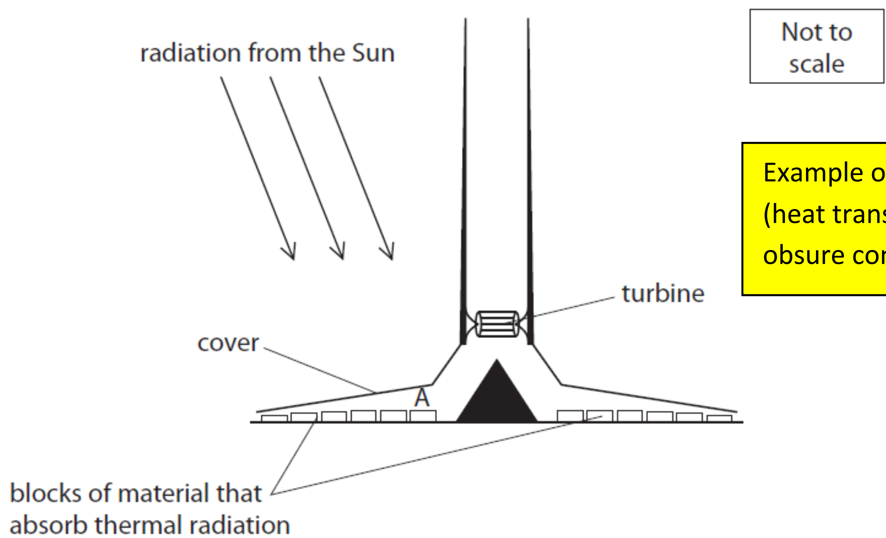
12 An experimental solar updraft tower (SUT) was built in the south of Spain.

This part of Spain has little rainfall and is hot in summer months.

The SUT was used as a 50 kW electricity generator.

The diagram shows the component parts of the tower.

The cover allows visible light to pass through but traps infrared. Rows of blocks under the cover absorb thermal radiation.



Example of a standard concept (heat transfer) that is used in an obsure context.

(a) (i) Explain what happens to the air at A just under the cover.

(3)

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(ii) On the diagram, mark the directions of the air movements over the blocks of material and through the turbine.

(2)

(iii) State the name of this effect.

(1)

....

(b) (i) Complete the energy transfer diagram for a SUT.

(2)

.... ⟶ .... ⟶ electrical

(ii) Describe how a SUT can be used to generate electricity.

(2)

....

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(c) (i) Suggest why the SUT generates most electricity during daylight hours.

(1)

....

....

(ii) Suggest why there are blocks of material that absorb thermal radiation in the SUT.

(1)

....

....

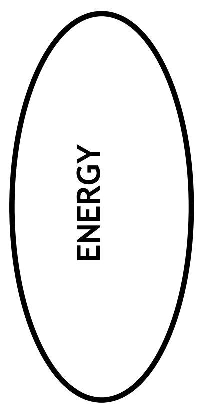
(iii) Suggest an alternative to these blocks that would improve the total energy output of the SUT.

(1)

....

....

(Total for Question 12 = 13 marks)


ENERGY