PiXL KnowIT!

GCSE Physics

Edexcel Conservation of energy

www.pixl.org.uk

The PiXL Club Ltd, Company number 07321607

Overview
Edexcel Topic 3

Conservation of energy

Part 1
- Energy stores
- Gravitational potential energy
- Kinetic energy
- Energy stores and transfers

Part 2
- Energy transfers in a system
- Energy efficiency
- Reducing unwanted energy transfers

Part 3
- Energy resources

LearnIT!
KnowIT!

Conservation of energy
Part 1

- Energy stores
- Gravitational potential energy
- Kinetic energy
- Energy stores and transfers

Energy stores and systems

Energy stores	Examples
Chemical	In food, fuel and electric batteries
Kinetic	In moving objects
Gravitational potential	In objects raised above a planets surface
Elastic potential	In a stretched, compressed or twisted object
Internal (thermal)	In any heated object
Magnetic	In any object with a magnetic field
Electrostatic	In electrostatic forces between charges
Nuclear	The forces acting between atomic nuclei

Force pathways include:

- Mechanically – when a force acts and an object moves
- Electrically – when an electric current flows
- Heating – a temperature difference between objects
- Radiation – electromagnetic waves or sound

Gravitational potential energy

When an object is raised above ground level it gains **gravitational potential energy** (GPE). This **stored energy** can be released if the object is allowed to **fall**.

A pile driver is a machine that lifts a heavy weight then drops it on a post to drive it into the ground.

Recall and use the equation to calculate the change in gravitational PE when an object is raised above the ground:

change in G.P.E (J) = mass (kg) × gravitational field strength (N/kg) × change in height (m)

$$\Delta GPE = m \times g \times \Delta h$$

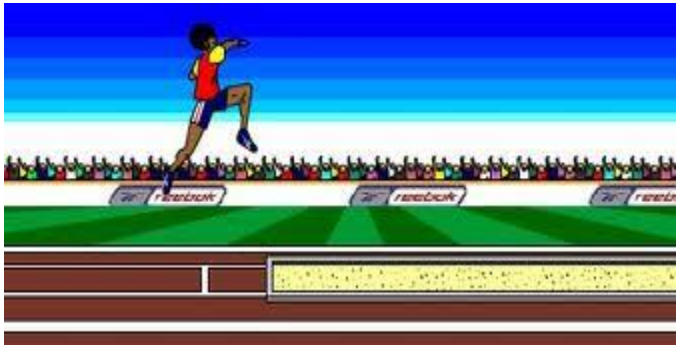
The pile driver hammer has a mass of 120 kg and it is raised to a height of 4 m above the ground. How much G.P.E will it have?

$$\Delta GPE = m \times g \times \Delta h$$

$$\Delta GPE = 120 \times 10 \times 4$$

The G.P.E gained is: Click to reveal answer

Kinetic Energy



Moving objects have kinetic energy.

The long-jumper is using her **kinetic energy** to carry her body as far as possible. The more kinetic energy she has, the longer her jump will be. Her kinetic energy depends on her mass (which she can not change) and her velocity (she can run faster!).

Recall and use the equation to calculate the amounts of energy associated with a moving object:

kinetic energy (J) = ½ × mass (kg) × speed² (m/s)

$$KE = \frac{1}{2} m v^2$$

If her mass is 46 kg and she is travelling at 8 m/s, her kinetic energy during her jump will be:

$$KE = \frac{1}{2} m v^2$$

$$KE = \frac{1}{2} \times 46 \times 8^2$$

The energy transferred in the jump is: Click to reveal answer

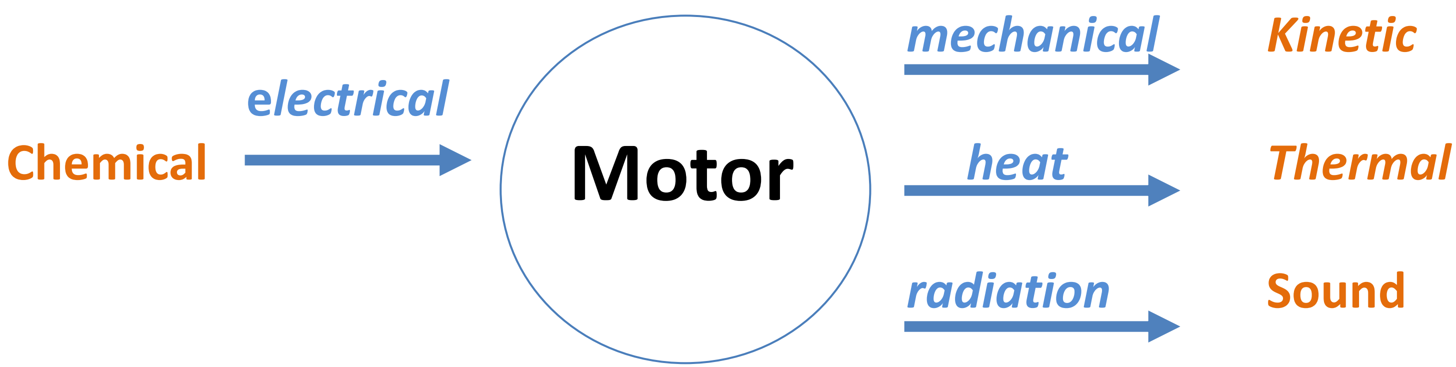
Energy stores and systems

An energy system is a group of objects that have the ability to do work.

Remember: energy can not be created or destroyed so when work is done, energy from one store is carried along a pathway to another energy store.

Consider the energy flow diagram for an electric shaver.

The battery has a store of chemical energy.
The current flows through an electrical pathway to the motor.
Energy from the motor follows a mechanical pathway to a kinetic store of the moving blades, a heat pathway to a thermal store and a radiation pathway to a sound store.



Energy stores and systems

Examples of energy changes in a system:

An object thrown (projected) upwards e.g. You throw a tennis ball upwards.

- As the **ball leaves** your **hand** it has a **store** of **kinetic energy**.
- At its **highest point** it has a **store** of **gravitational potential energy (G.P.E)**.
- As you are about to catch it just **before it hits your hand** it has a **store** of **kinetic energy.**

Energy stores and systems

Examples of energy changes in a system:

A moving object hitting an obstacle e.g. A bowling ball hitting a pin

- As you move the muscles of your arm to throw the ball the **chemical energy store** in your muscles **decreases** and the **kinetic energy store** of the bowling ball **increases.**
- At the ball hits a pin some of the **kinetic energy** has been transferred to a **store** of **internal (thermal) energy** this causes the ball and its surroundings to warm up a little.
- You will hear a **sound** when the ball hits the pin, the **energy of the sound** is also transferred to the **internal energy store** of the **surroundings**.

Energy stores and systems

Examples of energy changes in a system:

An object being accelerated by a constant force e.g. A bowling ball being dropped off a sky scraper

- At its **highest point** the ball has a **store** of **gravitational potential energy (G.P.E)**.
- As it is dropped **gravity** does work on the ball (assuming there is no air resisitance).
- The ball then constantly accelerates towards the ground.
- Just **before the ball hits the ground** it has a **store** of **kinetic energy.**

Energy stores and systems

Examples of energy changes in a system:

A vehicle slowing down e.g. When you apply the brakes in a lorry

- The **moving** lorry has a **store** of **kinetic energy**.
- At the **brakes** are applied the **kinetic energy store decreases** the energy is transferred to the **internal (thermal) energy store** in the brakes and the brakes get hot.
- You will hear a **sound** when the brakes of the lorry are applied, the **energy of the sound** is also transferred to the **internal energy store** of the **surroundings**.
- When the lorry **stops** its **kinetic energy store** is **zero**.

Energy stores and systems

Examples of energy changes in a system:

Bringing water to a boil in an electric kettle.

- Energy is transferred **electrically** from the mains to the **heating element** in the kettle.
- The **internal (thermal) energy store** of the water **increases.**
- The temperature of the water increases and as bubbles form the **kinetic energy store** of the water increases.

Energy is measured in Joules (J)

1 kilojoule (kJ) = 1000 J (10^3J)

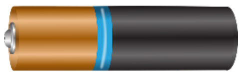
1 megajoule = 1000 000 J (10^6J)

QuestionIT!

Conservation of energy
Part 1

- Energy stores
- Gravitational potential energy
- Kinetic energy
- Energy stores and transfers

1. What sort of energy store do the following examples have?

a.  b.  c. 

2. Name and describe the four force pathways.

3. Write down the correct answer to complete the statement.

Energy can not.....

be transferred from one source to another.

be created or destroyed.

travel along a pathway to another store.

4. A pole vaulter just clears the bar which is 5.1 m high. His mass is 62 kg. **(g = 10N/kg)**

a. What type of stored energy does he have as he clears the bar?

b. Work out how much stored energy the pole vaulter has due to his position above the ground.

c. As he falls back to the ground, this energy store will be transferred into a new energy store. Name this new energy store.

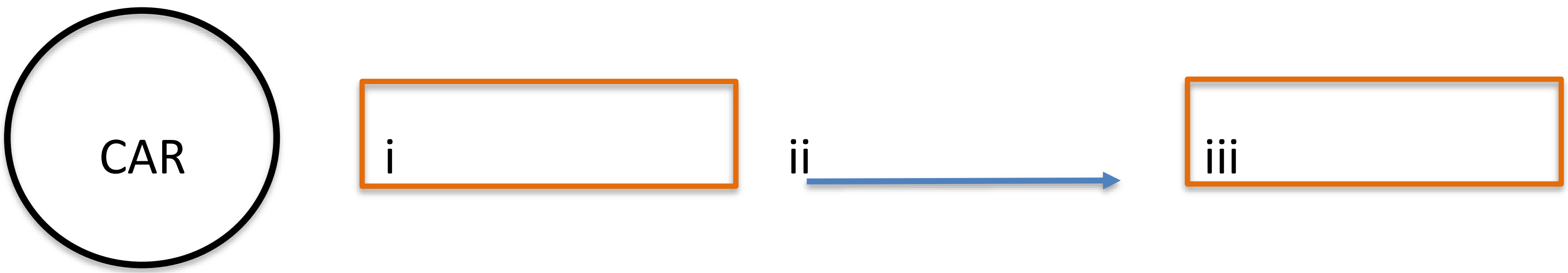
5. When a football is kicked it gains **kinetic energy**.

   a. What is the **formula** used to calculate kinetic energy?

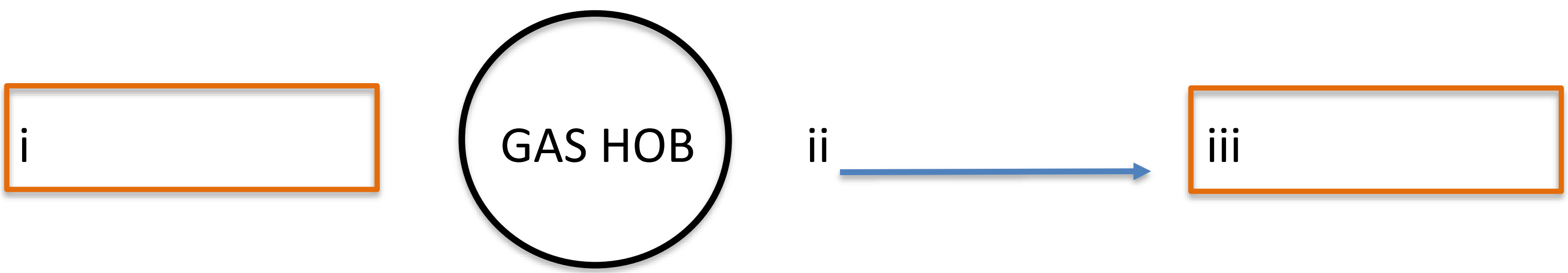
   b. The football has a mass of 0.4 kg and when kicked has a velocity of 15 m/s. Work out the **kinetic energy** of the moving ball?

6. Copy and Complete the **energy store** and **pathway** diagrams for the objects described.

a. A **moving** car **braking** to a stop.



b. Bringing water to the **boil** on a gas hob.



7. Describes the main change in **energy stores** for:

    a. A bowling ball hitting a pin

8. Describes the main change in **energy stores** for:

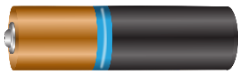
    b. Boiling water in an electric kettle

AnswerIT!

Conservation of energy
Part 1

- Energy stores
- Gravitational potential energy
- Kinetic energy
- Energy stores and transfers

1. What sort of energy store do the following examples have?

a. 

b. 

c. 

Chemical **Elastic potential** **Thermal**

2. Name and describe the four force pathways.

Mechanically – when a force acts and an object moves
Electrically – when an electric current flows
Heating – a temperature difference between objects
Radiation – electromagnetic waves or sound

3. Write down the correct answer to complete the statement.

Energy can not.....

be transferred from one source to another.
be created or destroyed. ✓
travel along a pathway to another store.

4. A pole vaulter just clears the bar which is 5.1 m high. His mass is 62 kg. **(g = 10N/kg)**

a. What type of stored energy does he have as he clears the bar?

gravitational potential energy

b. Work out how much stored energy the pole vaulter has due to his position above the ground.

$\Delta GPE = m \times g \times \Delta h = 62 \times 10 \times 5.1 = 3162$ J

c. As he falls back to the ground, this energy store will be transferred into a new energy store. Name this new energy store.

kinetic energy

5. When a football is kicked it gains **kinetic energy**.

a. What is the **formula** used to calculate kinetic energy?

$$KE = ½ \, m \, v^2$$

b. The football has a mass of 0.4 kg and when kicked has a velocity of 15 m/s. Work out the **kinetic energy** of the moving ball?

$$KE = ½ \times 0.4 \times 15^2$$

$$KE = 45 \text{ J}$$

6. Copy and Complete the **energy store** and **pathway** diagrams for the objects described.

a. A **moving** car **braking** to a stop.

CAR

i Kinetic

ii Mechanical →

iii Thermal

b. Bringing water to the **boil** on a gas hob.

i Chemical

GAS HOB

ii Heating →

iii Thermal

7. Describes the main change in **energy stores** for:

a. A bowling ball hitting a pin

- **As you move the muscles of your arm to throw the ball the chemical energy store in your muscles decreases and the kinetic energy store of the bowling ball increases.**
- **At the ball hits a pin some of the kinetic energy has been transferred to a store of internal (thermal) energy this causes the ball and its surroundings to warm up a little.**
- **You will hear a sound when the ball hits the pin, the energy of the sound is also transferred to the internal energy store of the surroundings.**

8. Describes the main change in **energy stores** for:

b. Boiling water in an electric kettle

- **Energy is transferred electrically from the mains to the heating element in the kettle.**
- **The internal (thermal) energy store of the water increases.**
- **The temperature of the water increases and as bubbles form the kinetic energy store of the water increases.**

PiXL
partners in excellence

LearnIT! KnowIT!

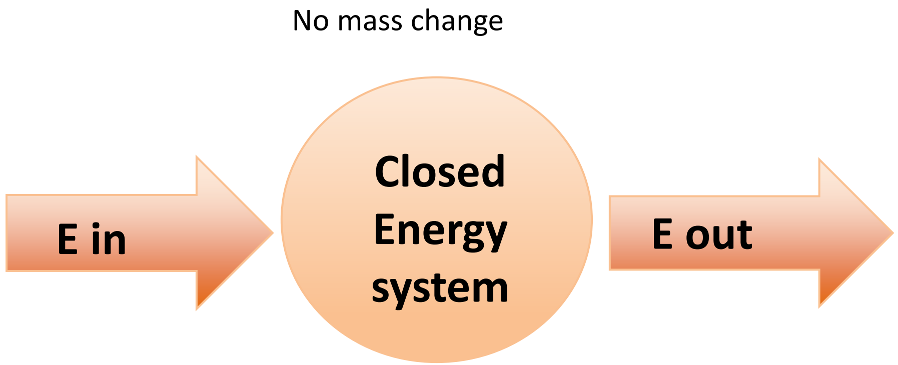
Conservation of energy Part 2

- Energy transfers in a system
- Energy efficiency
- Reducing unwanted energy transfers

Energy transfers in a system

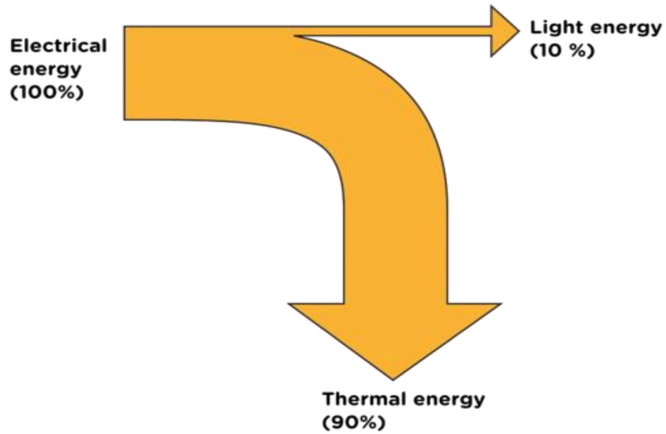
Energy can be stored, transferred or dissipated - but can not be created or destroyed.

In a closed energy system there can be transfer of energy but not mass. There is **no change to the total energy in the system.**



In a **closed energy system** all the energy can be accounted for even when energy stores change.

The diagram shows the energy transfer for a light bulb. All the electrical energy store can be accounted for as light energy and thermal energy.
The thermal energy is not useful in this case and can be considered to be dissipated or “waste” energy.



Energy transfers in a system

<u>Unwanted energy</u> transfers result in energy stores that are not useful.

The F1 car below shows that eventually all the chemical energy (fuel) put in the car ends up as unwanted thermal energy which is dissipated to the surroundings. Unwanted energy is often described as being 'wasted'

Chemical →  → Kinetic → Thermal

→ Sound → Thermal

→ Thermal

Kinetic energy is dissipated by the tyres, brakes and air resistance to become unwanted thermal energy stores.

Sound energy is absorbed by materials and becomes thermal energy.

Thermal energy is produced by the engine as fuel is burnt.

Oil is used in the engine, gearbox and other moving parts as a lubricant to reduce friction and reduce unwanted thermal energy in these parts.

Energy transfers in a system

Thermal insulation is often used to reduce unwanted energy transfers.

All the **energy** used to **heat a home** is eventually **transferred** as **thermal energy** to the **surroundings**.

The diagram, shows the percentage energy lost through different parts of the building.

Material	Thermal Conductivity W/m C
Air	0.03
Polyurethane foam	0.03
Fibreglass	0.04
Wool felt	0.05
Wood	0.15
Plaster	0.50
Glass	0.80
Brick	1.00
Concrete	1.04

The higher the thermal conductivity, the quicker heat is transferred through the material.

Houses are often built from brick, concrete, wood and glass. All have quite **high thermal conductivity** values. **Insulation** uses materials with low thermal conductivity, such as fibreglass in the loft, foam in wall cavities and trapped gases in double glazing.

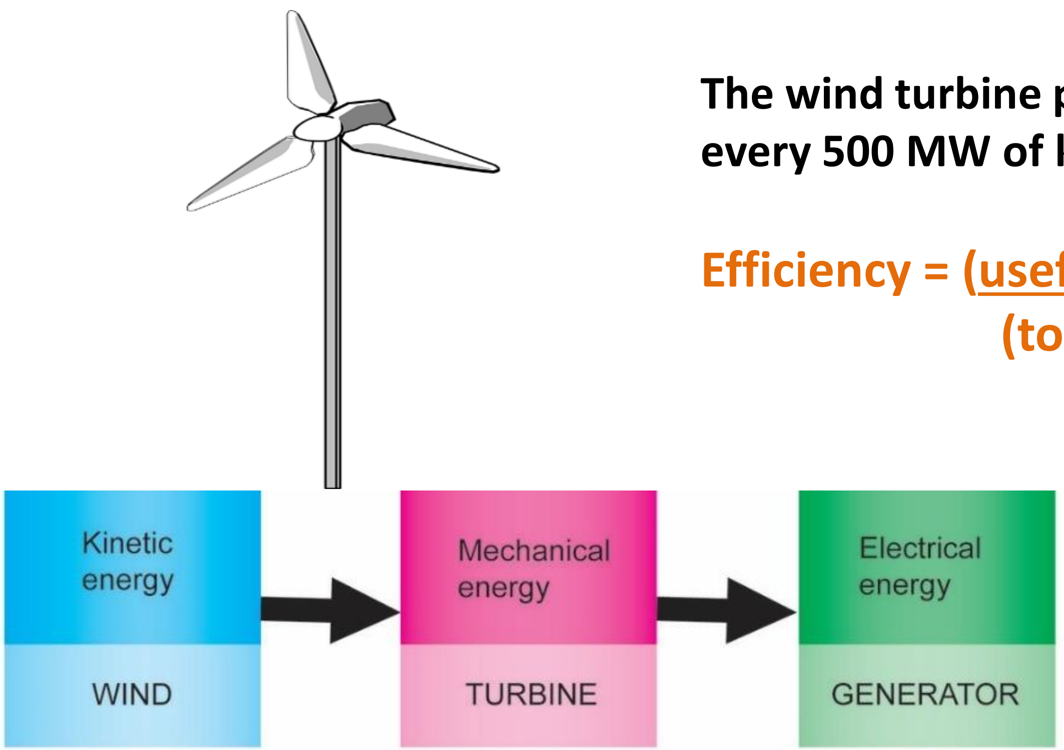
Efficiency

The amount of useful energy you get from an energy transfer, compared to the energy put in, is called the **EFFICIENCY**

Efficiency = (useful energy transferred by the device) / (total energy supplied to the device)

This calculation will result in a decimal value which can be multiplied by 100 to give a percentage efficiency.

A wind turbine energy transfer



The wind turbine produces 120 MW of electrical energy for every 500 MW of kinetic energy provided by the wind.

Efficiency = (useful energy transferred by the device) / (total energy supplied to the device)

$$= \frac{120}{500} = 0.24 \text{ efficient}$$

or 0.24 x 100 = 24 % efficient

Reducing unwanted energy transfers (Higher tier)

Different devices have different efficiency values. No device can be more 100% efficient.

Devices can waste in many ways, for example:

- **Friction (thermal energy)** between the moving part of a car or motorbike
- **Sound energy** when a hair drier is being used
- **Electrical** circuits heating (thermal energy) up due to resisitance
- **Thermal energy** being lost from the roof or wall of a house

Mechanical devices can be made more efficient by lubrication this reduces energy transferred by friction e.g. engine oil

Having good **insulation** reduces the rate of **thermal energy transfers** e.g. loft insulation

PiXL
partners in excellence

QuestionIT!

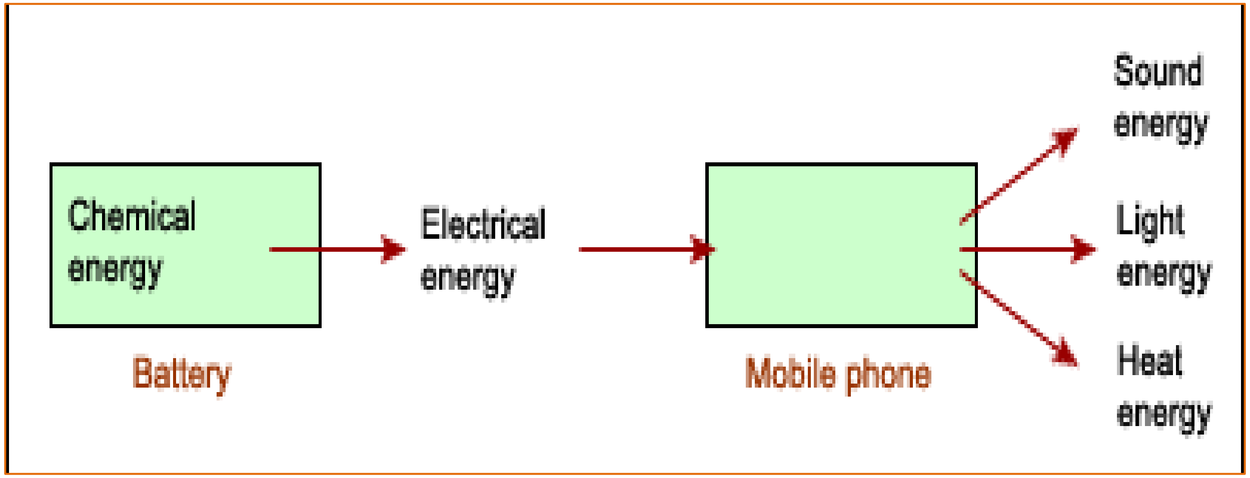
Conservation of energy
Part 2

- Energy transfers in a system
- Energy efficiency
- Reducing unwanted energy transfers

1. In a "closed" system ....
   A. energy can be transferred but there is no net energy loss.
   B. energy and mass are transferred in and out of the system.
   C. energy cannot be transferred between different energy stores.

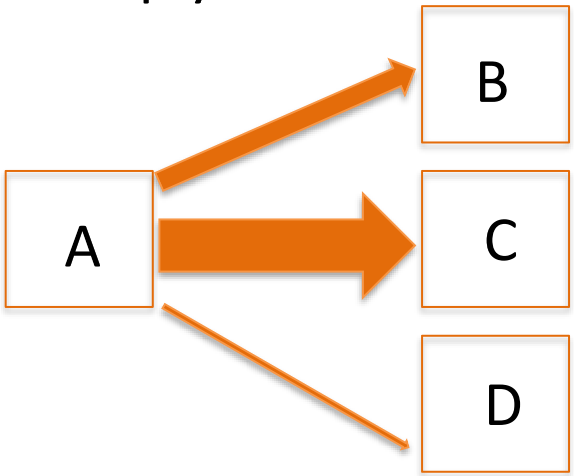
2. The energy transfer diagram for a mobile phone shows that 100 J of electrical energy produces 45 J of light energy and 36 J of sound energy.

How much thermal energy will be dissipated by the phone?



3. Describe how the thermal energy produced by a bus driving along a road is dissipated.

4. a. The diagram shows the main energy transfers for an electric fan. Complete boxes A to D showing the energy stores involved. Use the size of the arrows to help you.



b. State why the total energy supplied to an electric fan must always equal the total energy transferred by the electric fan.

5. a. The diagrams show two different types of loft insulation.

Fiberglass insulation   Wool insulation

The wool needs to be thicker to have the same insulating properties. Explain which material has the highest thermal conductivity?

b. Explain how trapped air reduces the rate of heat loss, in terms of thermal conductivity.

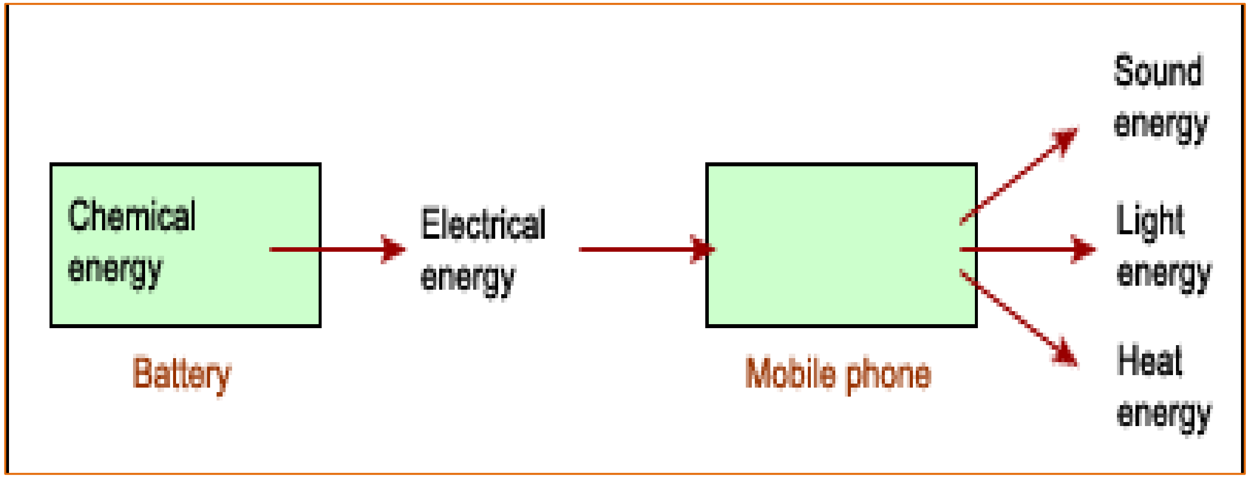
AnswerIT!

Conservation of energy
Part 2

- Energy transfers in a system
- Energy efficiency
- Reducing unwanted energy transfers

1. In a “closed” system ....
   A. energy can be transferred but there is no net energy loss. ✓
   B. energy and mass are transferred in and out of the system.
   C. energy cannot be transferred between different energy stores.

2. The energy transfer diagram for a mobile phone shows that 100 J of electrical energy produces 45 J of light energy and 36 J of sound energy.
How much thermal energy will be dissipated by the phone?



45 J + 36 J = 81 J

100 J – 81 J = 19 J

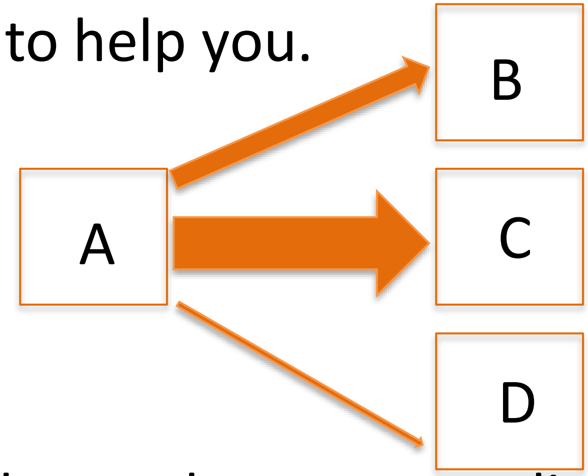
19 J of thermal energy will be dissipated

Part 2 - AnswerIT

3. Describe how the thermal energy produced by a bus driving along a road is dissipated.

The thermal energy increases the kinetic energy of the air particles therefore warming up the surroundings.

4. a. The diagram shows the main energy transfers for an electric fan. Complete boxes A to D showing the energy stores involved. Use the size of the arrows to help you.



A - Electrical energy

B - Thermal energy

C - Kinetic energy

D - Sound energy

b. State why the total energy supplied to an electric fan must always equal the total energy transferred by the electric fan.

Energy can not be created or destroyed so:

total <u>energy in = total energy out</u>

5. a. The diagrams show two different types of loft insulation.

Fiberglass insulation   Wool insulation

The wool needs to be thicker to have the same insulating properties. Explain which material has the highest thermal conductivity?

Wool has the highest thermal conductivity as it lets thermal energy through at a faster rate so a thicker layer is needed for the same insulation as the fiberglass.

b. Explain how trapped air reduces the rate of heat loss, in terms of thermal conductivity.

The air trapped inside the fiberglass acts as an insulator because air has a very low thermal conductivity and thermal energy can not pass through it easily.