Beatty Secondary School
Science Department (Chemistry Unit)
Chemistry 6092

Name: _____ ( ) Date: _____

Class: 3E___

TOPIC: PROPERTIES AND USES OF METALS AND ALLOYS (WORKSHEET 1)

Learning Objectives:

(a) Describe the general physical properties of metals as solids having high melting and boiling points, malleable, good conductors of heat and electricity in terms of their structure.

(b) Describe alloys as a mixture of a metal with another element, e.g. brass; stainless steel.

(c) Identify representations of metals and alloys from diagrams of structures.

(d) Explain why alloys have different physical properties to their constituent elements.

(e) Describe steels as alloys which are a mixture of iron with carbon or other metals and how controlled use of these additives changes the properties of the iron, e.g. high carbon steels are strong but brittle whereas low carbon steels are softer and more easily shaped.

(f) State the uses of mild steel, e.g. car bodies; machinery, and stainless steel, e.g. chemical plants; cutlery; surgical instruments.

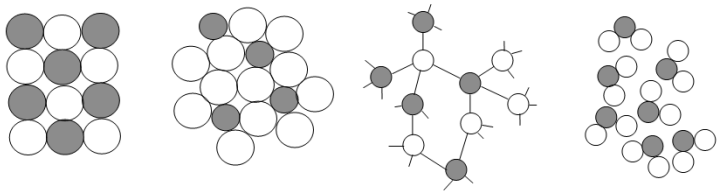
Multiple-Choice Questions

1 Layers of metal atoms can slide over each other. Which property is explained by this fact?

A Most metals have high melting points.
B Metals conduct electricity.
C Most metals have high densities.
D Metals are malleable. (**D**)

2 Which diagram best shows the structure of an alloy?

A **B** **C** **D**



(**B**)

3 Which alloy of iron is used in surgical instruments?

A high carbon steel **B** low carbon steel
C mild steel **D** stainless steel (**D**)

4 Which pair of elements **cannot** be used to form an alloy?

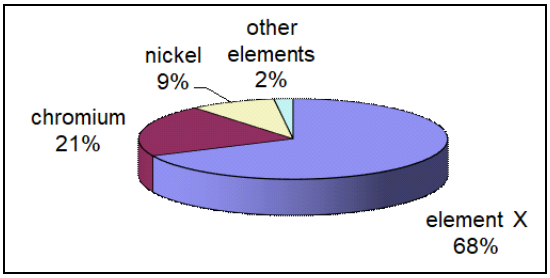
A aluminium and magnesium **B** chlorine and sodium
C copper and zinc **D** lead and tin (**B**)

5 Which row correctly lists the uses of metals?

	stainless steel	mild steel	aluminium
A	galvanising	car bodies	soft can drinks
B	car bodies	soft can drinks	galvanising
C	soft can drinks	aircraft bodies	pipes in chemical plants
D	cutlery	machinery	aircraft bodies

(**D**)

6 The composition of stainless steel is as shown below.



What is element X?

A carbon **B** copper
C iron **D** zinc (**C**)

7 High carbon steel is used in manufacturing processes.

1 It is brittle.
2 It is malleable.
3 It is soft.
4 It is strong.

Which properties does high carbon steel have?

A 1 and 2 **B** 1 and 4
C 2 and 3 **D** 3 and 4 (**B**)

8 Magnalium is an alloy of aluminium (85 %) and magnesium (15 %). Some properties of magnalium are listed below. Which property of magnalium is **not** a reason for its use in the construction of aircraft?

A It conducts electricity.
B It is less dense than aluminium.
C It is stronger than aluminium or magnesium.
D The surface of the alloy is covered by a layer of aluminium oxide. (**A**)

9 *Duralumin* is an aluminium alloy that contains copper. Which statement about *duralumin* is correct?

A It contains aluminium and copper that are chemically combined.
B It contains mobile electrons.
C It has a lattice of oppositely charged aluminium and copper ions.
D It has the same melting point as copper. (**B**)

10 Which statement about alloys is correct?

A They are good conductors of electricity as they have mobile ions.
B They are formed by a chemical reaction between two metals.
C They can be all represented by a molecular formula.
D Their structures contain a 'sea of electrons'. (**D**)

11 A student thinks that element Q is a metal because it has a high melting point and a high boiling point. What other properties could element Q have if it is a metal?

1 Q conducts electricity when solid.
2 Q forms an acidic oxide, QO_2.
3 Q is malleable.

A 1, 2 and 3 **B** 1 and 2 only
C 1 and 3 only **D** 2 and 3 only (**C**)

Structured questions

12 Over 90% of all the metal used in the world contains the element iron. Most iron is used in the form of the alloy steel.

(a) Explain what is meant by the term *element*.

An element is a pure substance that cannot be broken down into 2 or more simpler substances by chemical methods.

(b) Trains are mainly made up of steel. Some parts of trains are made of aluminium.

(i) Why is steel used in the train rather than pure iron?

Steel is an alloy and is stronger and harder than pure iron.

(ii) Suggest why some parts of a train are made of aluminium, rather than steel.

Aluminium has a lower density than steel, making it lighter for train parts. Aluminium forms a non-porous layer of oxide, which is resistant to corrosion.

(iii) Suggest why a train is not made completely out of aluminium.

Pure aluminium is soft and malleable as the layers of aluminium atoms can slide over each other easily when a force is applied. This causes the train to be easily damaged.

(c) The properties of steel depend on the percentage of carbon in the steel. Give one use for steel containing a **small** amount of carbon and state **one** difference in properties between this type of steel and steel containing a **large** amount of carbon.

use **car bodies / machinery**

difference in properties **Low carbon steel is softer and more easily shaped / malleable as compared to high carbon steel which is harder, stronger but brittle.**

13 Most soft drink cans are made from an alloy of aluminium.

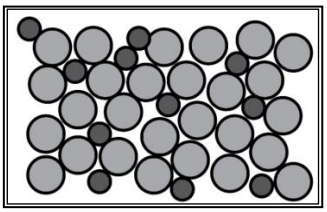
(a) What is an alloy?

A mixture of a metal with one or a few elements

(b) Name an alloy and state the elements it is composed of.

Brass – zinc and copper. Steel – iron and carbon

(c) Sketch a diagram to show how the atoms are arranged in the alloy and explain how the alloy is more desirable than that of a pure metal.



An alloy is stronger and harder than a pure metal. As atoms of different sizes are added for alloying, the orderly arrangement is disrupted, making it harder for the layer of atoms to slide over each other. On the other hand, the layer of the same-sized atoms in a pure metal can slide over easily which is soft and malleable, making the pure metal easier to be damaged.

14 Chemists have designed a wide variety of steels to suit particular uses. Some steels simply contain iron and carbon only, whereas others contain one or more other metals. The table shows the content and properties of some steels.

type of steel	content of steel	properties
mild steel	iron + 0.25 % carbon only	easily shaped, not brittle
high carbon steel	iron + 1.5 % carbon only	hard and brittle
cast iron	iron + 4 % carbon only	very hard and very brittle
stainless steel	iron + 18 % chromium + 8 % nickel	tough and does not corrode

(a) Give **two** effects of increasing the percentage of carbon in steel.

As the percentage of carbon in steel increases from 0.25 % in mild steel to 4 % in cast iron, the steel becomes harder, less easily shaped and more brittle.

(b) Explain the type of steel you would choose to make hip replacement joints.

choice **stainless steel**

reason

Hip replacement joints should be durable, lightweight, tough and resistant to corrosion to allow patients to be continue with daily activities without worrying about fractures and immobilities.

15 The table below lists some of the properties and composition of a selection of alloys.

alloy	composition	strength (MPa)	density (g/cm^3)	properties
mild steel	99.75 % iron 0.25 % carbon	841	7.85	easily pressed into shape
brass	67 % copper 33 % zinc	550	8.55	soft, easy to cast
bronze	88 % copper 12 % tin	500	8.70	weather resistant, durable
stainless steel	…….. iron 18 % chromium 8 % nickel	860	7.86	resists corrosion
duralumin	95 % aluminium 4 % copper 1 % magnesium	483	2.79	strong, hard, lightweight

(a) **(i)** State which alloy is the densest.

bronze

(ii) Complete the table by calculating the percentage of iron in stainless steel.

74.0 %

(b) The statue of King George IV in Trafalgar Square, London is shown. It has been on the show since 1843.

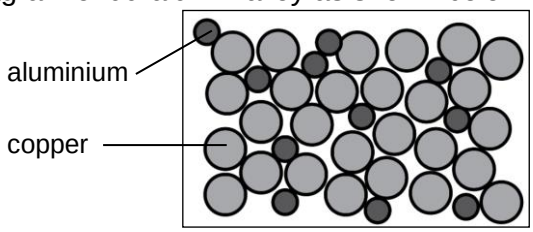
State the name of the alloy used to make the statue and explain your answer.

name **bronze**

reason **The statue has been able to withstand many years without being destroyed under any weather conditions. Hence, the material used for the statue should be weather resistant and durable.**

(c) With reference to data, a student drew a diagram of duralumin alloy as shown below.

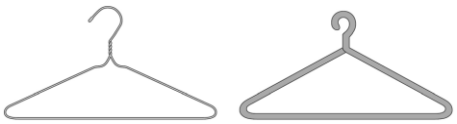
element	atomic radius (nm)
aluminium	0.184
copper	0.140
magnesium	0.173



Give reasons why the diagram is **not** an accurate representation of the arrangement of atoms in duralumin.

1. **With reference to the diagram, the size of an aluminium atom is smaller than the size of a copper atom. However, this is not accurate as the atomic radius of an aluminium atom (0.185 nm) is larger than the atomic radius of a copper atom (0.140 nm).**
2. **Duralumin is an alloy consisting of aluminium (95%), copper (4%) and magnesium (1%) atoms. However, magnesium atoms are absent in the diagram.**
3. **With reference to the diagram, the proportion / percentage of copper atoms is much larger than aluminium atoms, which is not an accurate representation of the ratio 95 : 4.**

16 Clothes hangers are often made from two materials, steel and plastics. The table gives information from a Life Cycle Assessment (LCA) comparing these two clothes hangers.



	Steel wire hanger	**Plastic hanger**
Raw materials	Iron ore, air, coal, limestone	Crude oil
Manufacturing process	Coal is heated at 1000°C to make coke. Iron ore is heated with coke, limestone and air to 1600 °C. This produces impure molten iron. Impure molten iron is converted to steel by adding oxygen at 1700°C.	Crude oil is heated to 350 °C for fractional distillation. A fraction is cracked at 850 °C to produce alkenes. Alkenes are polymerised at 150 °C.
Use during its lifetime	May corrode over time.	Does not corrode.
Disposal at the end of its life	Landfill, where it will corrode. Can be recycled.	Landfill/Not biodegradable. Can be incinerated (burnt). Difficult to recycle.

Cost
Usefulness
Energy / Efficiency
Environment

(a) Using the information above, explain one advantage and disadvantage for **each** type of hanger.

Disadvantages of steel wire hangers:
1. **Steel wire hangers corrode over time because the iron in steel can rust.**
2. **The manufacturing process of steel is more expensive / costly because a high temperature of up to 1700 °C is required, implying more energy is needed.**
3. **Steel wire requires the use of more raw materials than plastic hanger.**

Advantage of steel wire hangers:
1. **Steel wire hangers are more environmentally friendly because it does not take up spaces in the landfill sites as they can be recycled.**

Disadvantages of plastic hangers:
1. **Plastic hangers are non-environmentally friendly as they are non-biodegradable and causes air pollution when burnt.**

Advantages of plastic hangers:
1. **Plastic hangers have a lower cost of manufacturing as lower temperatures of up to 850 °C is required, implying lesser energy is needed.**
2. **Plastic hangers can be used over a longer period of time because they do not corrode over time**

(b) While a steel wire hanger seemed to be more environmentally friendly than a plastic hanger, a student argued that this is **not** necessarily true. Explain why the student might be correct.

During the manufacturing process of a steel wire hanger, high temperatures of up to 1700 °C is required. As such, in order to produce the high temperatures, there would be an increase in the combustion of fossil fuels, leading to an increase in the emission of harmful gases, causing air pollutions.