Beatty Secondary School
Science Department (Chemistry Unit)
Chemistry 6092

Name: _____ (   )   Date: _____

Class: 4E____

TOPIC: EXTRACTION OF METALS AND RECYCLING (WORKSHEET 3)

Learning Objectives:

(a)   Describe the ease of obtaining metals from their ores by relating the elements to their positions in the reactivity series.

(b)   Describe and explain the essential reactions in the extraction of iron using haematite, limestone and coke in the blast furnace.

(c)   Describe metal ores as a finite resource and hence the need to recycle metals, e.g. recycling of iron.

(d)   Discuss the social, economic and environmental issues of recycling metals.

Multiple-Choice Questions

1   Which metal can be extracted by heating its oxide with carbon?

A	calcium	**B**	magnesium
C	potassium	**D**	zinc

(**D**)

2   The positions of four metals in the reactivity series is shown below.

W   X   Y   Z
reactivity increases ➡

Which metals are **most likely** to be extracted by electrolysis and by heating their oxides with coke?

	extraction by electrolysis	extraction by heating the oxide with coke
A	metal Z	metal W
B	metal X	metal Y
C	metal Y	metal Z
D	metal W	metal Z

(**A**)

3   Which reaction produces most of the carbon monoxide used to extract iron in the blast furnace?

A   burning coke in air
B   reacting coke with carbon dioxide
C   reacting iron oxide with coke
D   decomposition of limestone

(**B**)

4 Which substance is added to the blast furnace to remove impurities from iron ore?

A	carbon	**B**	haematite
C	limestone	**D**	slag

(**C**)

5 Some metals can be extracted by heating their oxides with hydrogen. Which metal is most easily extracted by this method?

A	calcium	**B**	copper
C	sodium	**D**	zinc

(**B**)

6 Which substance does **not** have to be added to the blast furnace in the extraction of iron?

A	air	**B**	coke
C	limestone	**D**	sand

(**D**)

7 Which is **not** a reason for recycling metals?

A There are limited amounts of metals in the Earth's crust.
B Energy is needed to extract new metals from their ores.
C Pollution of land from discarded metals is prevented.
D Energy is used in recycling metals.

(**D**)

8 Titanium metal can be extracted by the reaction below.

$$TiCl_4 + 4Na \rightarrow Ti + 4NaCl$$

What deduction can be made about titanium from this reaction?

A Titanium is above sodium in the reactivity series.
B Titanium can also be obtained by heating its oxide with coke.
C Sodium is more reactive than titanium.
D Titanium can also be extracted by heating $TiCl_4$ with aluminium.

(**C**)

9 In the manufacture of iron by the blast furnace, which are the main gases that escape from the top of the blast furnace?

A carbon monoxide, carbon dioxide, hydrogen.
B nitrogen, carbon dioxide, carbon monoxide
C nitrogen, oxygen, steam
D oxygen, carbon dioxide, sulfur dioxide

(**B**)

10 Which statement about the production of iron from haematite is correct?

A Coke is used to oxidise slag.
B Limestone is used to produce oxygen for the coke to burn.
C Molten iron floats on slag at the furnace base.
D The haematite is reduced by carbon monoxide.

(**D**)

11 In the table below, the first substance is added to the Blast Furnace and the second substance is the main impurity in the iron formed.
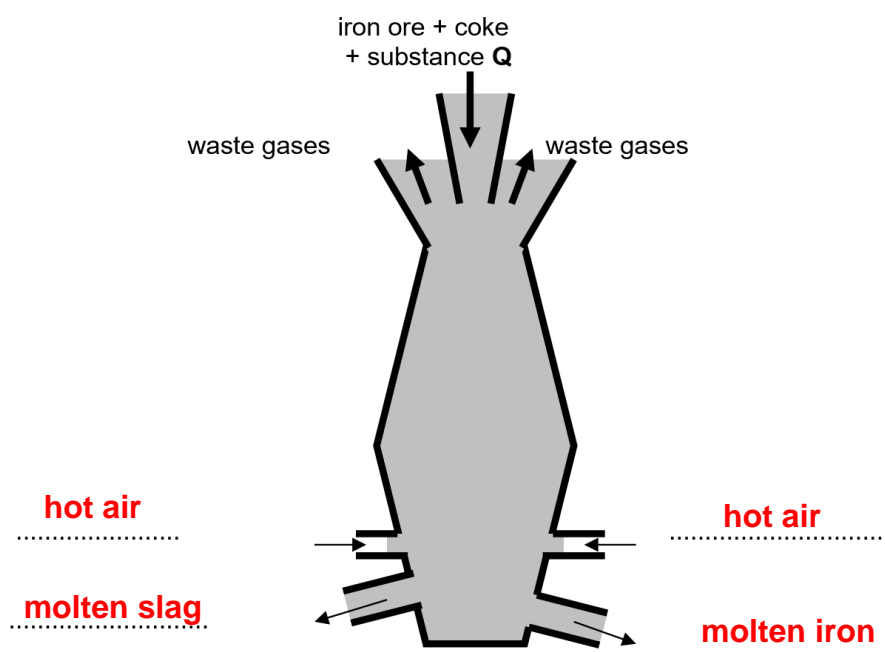
Which pair of substances is correct?

	substance added to the Blast Furnace	main impurity in the iron formed
A	calcium oxide	silica
B	limestone	carbon
C	quicklime	iron(II) oxide
D	slaked lime	iron(III) oxide

(**B**)

Structured Questions

12 The diagram shows the blast furnace for the extraction of iron.

iron ore + coke
+ substance **Q**

waste gases   waste gases

hot air   **hot air**

molten slag   **molten iron**

(a) Add the four missing labels to the diagram.

(b) Name one iron ore and give its chemical name.

iron ore: **haematite**   chemical name: **iron(III) oxide**

(c) **(i)** Name substance **Q**.

limestone

(ii) Explain why **Q** is added to the blast furnace.

Limestone is added to remove sand impurities / acidic impurities from the ore.

(d) The iron ore reacts with a gaseous reducing agent to produce molten iron.

(i) Name the reducing agent.

carbon monoxide

(ii) Write the equation for the **production of this reducing agent**.

$C + CO_2 \rightarrow 2CO$

(e) Explain why the temperature of slag coming out of the tap hole is much lower than the expected 1530 °C.

The slag is a mixture containing impurities that lower the melting point.

(f) Suggest why the furnace would explode if the damp substances of the raw materials were added at the top of the furnace.
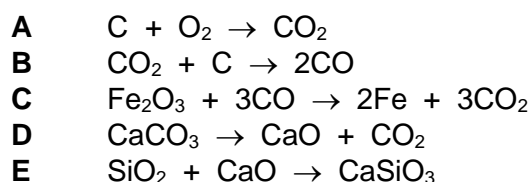
Iron and carbon would reduce the steam (water that is heated at high temperature) to hydrogen. The hydrogen would react with the oxygen in air to release a large amount of energy, leading to explosion.

13 Explain why carbon can be used to obtain iron from iron oxide but not to obtain calcium from calcium oxide.

Carbon is more reactive than iron, but less reactive than calcium in the reactivity series. As such, carbon is able to displace / reduce iron from iron oxide to form iron, but unable to displace / reduce calcium from calcium oxide. As such, calcium can only be obtained through electrolysis.

14 Iron is extracted from iron ore in the Blast Furnace.

The equations **A**, **B**, **C**, **D** and **E** show some reactions that happen in the Blast Furnace.

A $\quad C + O_2 \rightarrow CO_2$
B $\quad CO_2 + C \rightarrow 2CO$
C $\quad Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$
D $\quad CaCO_3 \rightarrow CaO + CO_2$
E $\quad SiO_2 + CaO \rightarrow CaSiO_3$

Use the letters, **A**, **B**, **C**, **D** and **E** to answer the following questions.

(a) Which equation shows combustion? **A**

(b) Which equation shows thermal decomposition? **D**

(c) Which equation shows a reaction between an acidic compound and a base?

E

(d) Which equation shows the formation of a toxic gas?   **B**

(e) Two equations show different elements in compounds being reduced. Give the letters for these **two** equations.

B   and   **C**

(f) Iron from the Blast Furnace is further processed to make steel. Some types of steel contain more carbon than others.

How are the properties of high carbon steel different from those of low carbon steel?

High carbon steel is stronger and harder than low carbon steel.
High carbon steel is less malleable/more brittle than low carbon steel.

15 The table gives some information on four metals.

	magnesium Mg	platinum Pt	nickel Ni	zinc Zn
percentage abundance in the Earth's crust	1.9	0.0001	0.008	0.007
approximate annual world production / millions of tonnes	0.3	0.001	1	500
main compound from which metal is extracted	$MgCl_2$	found as the element	NiS	ZnS
metal approximate price / S\$ per kg	7	40000	10	1.4
position in the Reactivity Series [also compared with aluminium, iron and copper]	above aluminium	below copper	between zinc and copper	between aluminium and iron
percentage of metal which is recycled	15	>90	25	25

(a) Which metal is most abundant in the Earth's crust.   **magnesium**

(b) Arrange the four metals in order of reactivity, placing the most reactive first.

magnesium, zinc, nickel and platinum

(c) Suggest, with a reason, the method used to extract

(i) nickel,

Metals that are below zinc in the reactivity series are extracted by reduction with carbon. Since nickel is between zinc and copper in the reactivity series, nickel can be extracted through reduction with carbon.

(ii) magnesium.

Metals that are above zinc in the reactivity series are extracted by electrolysis. Since magnesium is above zinc and aluminium in the reactivity series, magnesium can be extracted through electrolysis of its molten ore.

Suggest one reason why

(i) platinum is the most expensive metal,

It has the lowest percentage abundance of 0.0001 and the lowest annual world production of 0.001 million of tonnes, indicating that platinum is rare.

(ii) magnesium is much more expensive than zinc.

Magnesium is extracted by electrolysis whereas zinc is extracted by reduction with carbon. Electrolysis is much more expensive as much more energy is required.

(d) Of the four metals, platinum is the only one found naturally as the element. Suggest a reason for this.

Platinum is less reactive than copper. Hence, platinum is unreactive and does not combine with other elements in the Earth's crust.

(e) Suggest a reason why the annual production of zinc is much greater than that of nickel.

There is a greater demand of zinc for use as compared to nickel.

(f) Suggest **two** reasons for the differences in the percentages of platinum and nickel which are recycled.

Platinum is a rare metal and that platinum is more expensive than nickel.

(h) **(i)** Calculate the minimum mass of nickel sulfide ore, NiS, required to produce 1000 tonnes of nickel metal. [A_r: S = 32; Ni = 59]

no of moles of Ni = $\dfrac{1000 \times 10^6}{59}$

comparing mole ratio,

$$\text{Ni : NiS}$$
$$1 : 1$$

minimum mass of NiS = $\dfrac{1000 \times 10^6}{59}$ × (59 + 32) = 1540 tonnes

(ii) Suggest one possible environmental problem that might be caused in this extraction.

Sulfur dioxide may be formed in the process. Sulfur dioxide can react with oxygen and rainwater to form acid rain, which will corrode metal/limestone buildings or kill aquatic lives.