Reactivity of Metals

Part E: Reactivity of Metal

Reactivity is the readiness to react. Different metals may have different reactivity. To compare reactivity of metals, we usually base on three factors:

- The temperature at which the reaction starts
- The rate (speed) of reaction
- The amount of heat energy given out during reaction

Key:

Red words – Answers from Crocodile

Blue words – Answers from textbook

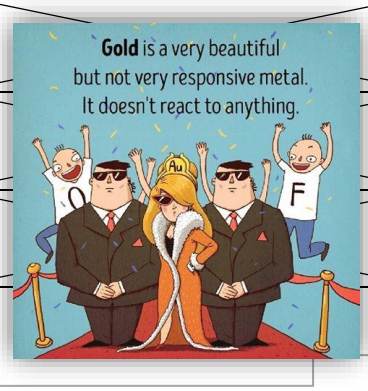
Continue on next page…

E-1: Reactions of metals with air

Question 7:

Complete the following table:

Metal	Heat needed to start reaction	Observation	Chemical equation for the reaction
Potassium (K)	gentle	burns vigorously with a lilac flame; a white smoke forms; a yellow powder forms	$4K(s) + O_2(g) \rightarrow 2K_2O(s)$ Metal + Oxygen → Metal oxide
Sodium (Na)	gentle	burns vigorously with a golden yellow flame; a white smoke forms; a white powder forms	$4Na(s) + O_2(g) \rightarrow 2Na_2O(s)$
Calcium (Ca)	strong	burns quite vigorously with a brick-red flame; a white powder forms	$2Ca(s) + O_2(g) \rightarrow 2CaO(s)$
Magnesium (Mg)	strong	burns with a very bright white light; a white powder forms	$2Mg(s) + O_2(g) \rightarrow 2MgO(s)$
Aluminium (Al)	strong	burns with white sparks; a white powder forms	$4Al(s) + 3O_2(g) \rightarrow Al_2O_3(s)$
Zinc (Zn)	strong	a powder (yellow when hot but white when cold) forms	$2Zn(s) + O_2(g) \rightarrow 2ZnO(s)$
Iron (Fe)	strong	iron powder burns with sparks; a black solid forms	$*3Fe(s) + 2O_2(g) \rightarrow FeO•Fe_2O_3(s)$ $*3Fe(s) + 2O2(g) \rightarrow Fe_3O_4(s)$
Lead (Pb)	strong	a powder (orange when hot but yellow when cold) forms on the surface	$2Pb(s) + O_2(g) \rightarrow 2PbO(s)$
Copper (Cu)	very strong	a black powder forms on the surface	$2Cu(s) + O_2(g) \rightarrow 2CuO(s)$
Mercury (Hg)	very strong	a red powder forms on the surface	$2Hg(l) + O_2(g) \rightarrow 2HgO(s)$
Silver (Ag)		no observable change	
Platinum (Pt)		no observable change	
Gold (Au)		no observable change	



E-2: Storage of metals

To prevent reaction with air, very reactive metals, e.g. potassium and sodium, are stored under paraffin oil. Calcium, which is quite reactive, is kept in an airtight container and stored in desiccator.

E-3: Reactions of metals with water

To find out how metals react differently with water, we add each metal under test to cold water. If there is no reaction, we then use hot water or even steam.

Question 8:

(a) Complete the following table about the reactions between the metals and ***cold water***:

Metal	Observation	Chemical equation for the reaction
Potassium (K)	➢ (1) Potassium dissolves gradually, melts to form a silvery ball, (2) which moves rapidly on the water surface ➢ (3) burns with a lilac flame ➢ (4) Hissing sound and (5) heat is produced. ➢ (Not observable: hydrogen gas produced)	$2K(s) + 2H_2O(l) \rightarrow 2KOH(aq) + H_2(g)$ Metal + Water → Metal hydroxide + Hydrogen (When K, Na, Ca reacts with steam, they form metal oxide and hydrogen like below)
Sodium (Na)	➢ (1) Sodium dissolves gradually, melts to form a silvery ball, (2) which moves rapidly on the water surface ➢ (3) It does not burn spontaneously, but if it burns, it burns with a golden yellow flame ➢ (4) Hissing sound and (5) heat is produced. ➢ (Not observable: hydrogen gas produced)	$2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$ Test for hydrogen: Burning splint, pop sound Test for alkali (hydroxide): Red litmus paper, from red to blue
Calcium (Ca)	➢ (1) Calcium dissolves gradually ➢ (2) sinks in water ➢ (3) evolves colourless gas bubbles (Not observable: hydrogen gas) ➢ (4) milky solution is formed, (5) heat is produced	$Ca(s) + 2H_2O(l) \rightarrow Ca(OH)_2(s) + H_2(g)$

(b) Complete the following table about the reactions between the metals and ***steam***:

Metal	Observation	Chemical equation for the reaction
Magnesium (Mg)	produces a very bright white light: a white powder remains	$Mg(s) + H_2O(g) \rightarrow MgO(s) + H_2(g)$ Metal + Water → Metal Oxide + Hydrogen
Aluminium (Al)	reacts when the oxide layer is removed; a white powder is formed	$2Al(s) + 3H_2O(g) \rightarrow Al_2O_3(s) + 3H_2(g)$
Zinc (Zn)	glows as steam is passed over, producing a yellow powder the yellow powder becomes white when it is left to cool	$Zn(s) + H_2O(g) \rightarrow ZnO(s) + H_2(g)$
Iron (Fe)	heat until it glows red before steam is passed over a black solid is formed	$3Fe(s) + 4H_2O(g) \rightarrow Fe_3O_4(s) + 4H_2(g)$

Part F: Reactions of Metals with Dilute Hydrochloric Acid

Reactive metals react with dilute acids (except dilute nitric acid) to produce ***salts*** and ***hydrogen gas***.

metal + dilute hydrochloric acid → metal chloride + hydrogen

metal + dilute sulphuric acid → metal sulphate + hydrogen

Heat is also given during the reaction.

Question 11:

Write the chemical equations for the reactions between:

(a) magnesium and dilute hydrochloric acid

$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$

(b) calcium and dilute hydrochloric acid

$Ca(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2(g)$

(c) zinc and dilute hydrochloric acid

$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$

(d) zinc and dilute sulphuric acid

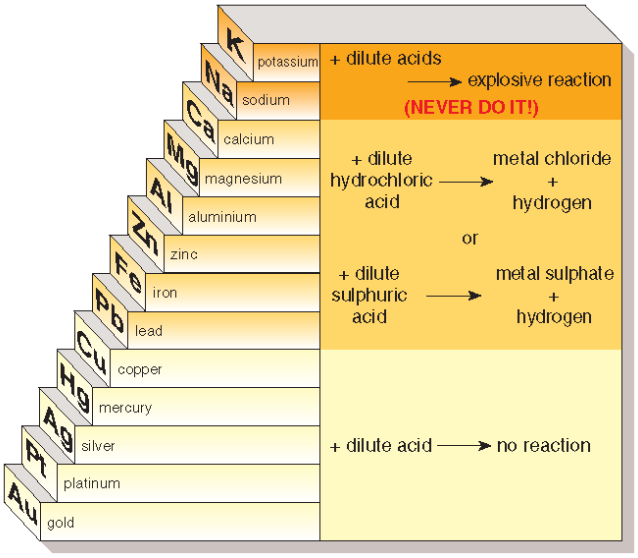
$Zn(s) + H_2SO_4(aq) \rightarrow ZnSO_4(aq) + H_2(g)$

(e) iron and dilute sulphuric acid

$Fe(s) + H_2SO_4(aq) \rightarrow FeSO_4(aq) + H_2(g)$

(f) copper and dilute sulphuric acid

No reaction



Observable changes (from calcium to lead):

Metal dissolves forming a colorless solution with colorless gas evolves.

For Fe:

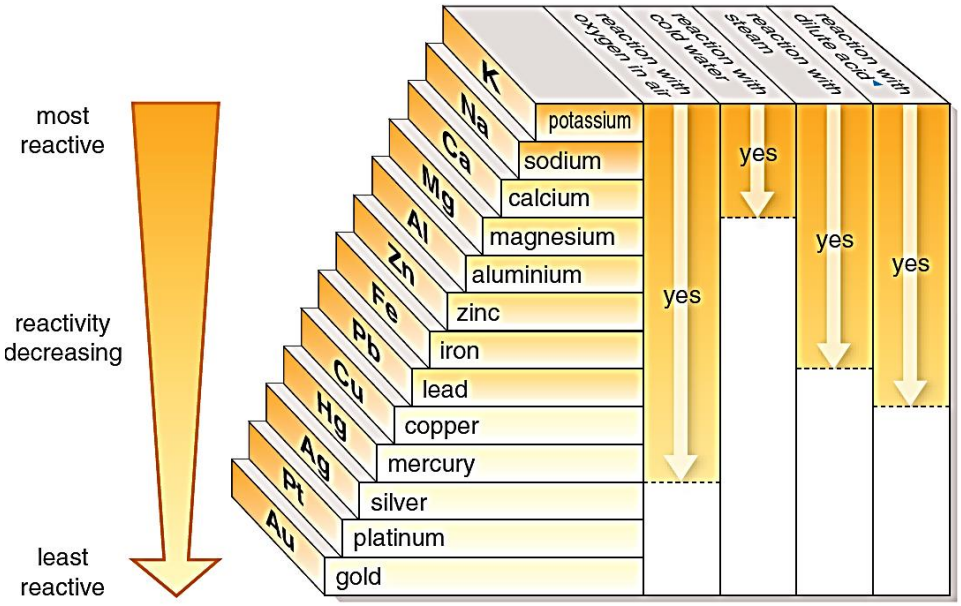
Iron dissolves forming a pale green solution with colorless gas evolves.

For Ca, Pb:

Calcium sulphate/ Lead sulphate/ Lead chloride is insoluble in water and covers the surface to prevent further reaction.

Part G: Metal Reactivity Series

From the reactions of metals with oxygen, water / steam and dilute acids, the metals can be arranged in a list of decreasing reactivity. This order is called the reactivity series.



Part H: Reactivity series and reduction of metal oxides

Metals react with oxygen in the air to form metal oxides. Metal oxides can be reduced to metals again. Compounds of a less reactive metal are more unstable. Thus, it is easier to reduce the oxide of the metal.