ACIDS AND BASES

We encounter acids and bases in everyday life. These are substances that have a pH greater or lower than 7, and they can be mildly to extremely harmful and corrosive. Any substance with a pH of 7 is said to be neutral.

pH	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Battery acid		Vinegar			Milk		Distilled water				Antacids		Ammonia	Bleach

QUESTION 1

Classify the following substances as either acidic or basic, and say whether they have a pH >7 or a pH<7 (based on your previous knowledge of the topic).

	SUNSTANCE	ACIDIC OR BASIC	pH
1.1	Fanta Orange	acidic	pH <7
1.2	Lux soap	basic	pH>7
1.3	tap water	acidic	pH<7
1.4	Colgate toothpaste	basic	pH>7
1.5	Handy Andy	basic	pH>7
1.6	Sunlight dishwashing liquid	basic	pH>7
1.7	Vitamin C	acidic	pH<7
1.8	blood	basic	pH>7
1.9	tartar sauce	acidic	pH<7
1.10	baking powder	acidic	pH<7

PROPERTIES OF ACIDS

- All acids contain hydrogen. It is responsible for the properties of acids.
- They are sour to taste
- Have a pH below 7
- Ionise in water to produce H^+ ions

- The temperature rises when acids are diluted in water, which indicates that an exothermic reaction takes place.
- All acids that are diluted with water form hydronium ions / H_3O^+ ions

  e.g $HCl(aq) \rightarrow H^+(aq) + Cl^-(aq)$

  But H^+ ions cannot exist on their own in solution, thus they combine with a water molecule to produce hydronium ions / oxonium ions : formula H_3O^+

  e.g. $H^+ + H_2O \rightarrow H_3O^+$

NAME OF ACID	MOLECULAR FORMULA	PHASE AT ROOM TEMPERATURE AND USES	STRENGTH
hydrochloric acid	HCl	Colourless liquid. Swimming pool acid, diluted as stomach acid, cleaning of metal surfaces.	strong
sulphuric acid	H_2SO_4	Colourless oily liquid. In car batteries, production of fertilizers, paints & cleaning agents.	strong
nitric acid	HNO_3	Colourless liquid. Production of fertilizers and explosives.	strong
phosphoric acid	H_3PO_4	Colourless liquid. Used as an acidifying agent to give colas their tangy flavour. Also used to remove rust.	weak
carbonic acid	H_2CO_3	Usually only found in solution. Added to drinks like soda to make them fizzy.	weak
acetic acid	CH_3COOH	Colourless liquid.	weak

		Vinegar.	
oxalic acid	$(COOH)_2$	White powdery solid. In bleaching agents, removing of rust.	weak

COMMON HOUSEHOLD ACIDS

These include citrus fruits, fizzy drinks like Cola, soda water and sparkling water, as well as cleaning products like pool chemicals and even medications like aspirin.

LABORATORY ACIDS

PROPERTIES OF BASES

- Feel soapy
- Have a pH above 7
- If a base (solid) is soluble in water, it is known as an alkali.
- If bases are diluted in water, the temperature rises, which indicates that an exothermic reaction has taken place.
- All bases which dilute with water form hydroxide ions :
  formula OH^-

  e.g. $NaOH\ (s) \leftrightarrows OH^-(aq) + Na^+(aq)$

COMMON HOUSEHOLD BASES

These include household and body cleaning products e.g soaps, shampoo, drain cleaner, bleach, toothpaste and dishwashing liquid and cleaning products.

LABORATORY BASES

NAME OF BASE	MOLECULAR FORMULA	PHASE AT ROOM TEMPERATURE AND USES	STRENGTH
potassium hydroxide	KOH (potash)	White crystalline solid. Neutralisation of acidic soil, paper production.	strong
sodium hydroxide	NaOH (Caustic soda)	White crystalline solid. Production of soaps and paper, cleaning agents.	strong
calcium hydroxide	$Ca(OH)_2$	Colourless crystal or white powder. Used in water and sewage treatment.	strong
magnesium hydroxide	$Mg(OH)_2$	White solid. Used as an antacid to neutralize stomach acid e.g. Milk of Magnesia.	strong
sodium hydrogen carbonate / (sodium bicarbonate)	$NaHCO_3$ (Baking soda or bicarbonate of soda)	White crystalline powdery solid. Used in baking.	weak
sodium carbonate	Na_2CO_3 (washing soda or soda ash)	White crystalline powdery solid. Glass production and softening of water.	weak
calcium carbonate	$CaCO_3$	White crystalline solid. Cement production, decorative bricks.	weak
ammonia	NH_3	Cleaning agents. Also present in urea (urine)	weak

SOME ACIDS AND BASES FOR YOU TO MEMORISE

ACID	FORMULA	BASE	FORMULA
hydrochloric acid	HCl	sodium hydroxide	NaOH
sulfuric acid	H_2SO_4	potassium hydroxide	KOH
sulfurous acid	H_2SO_3	sodium carbonate	Na_2CO_3
ethanoic acid/acetic acid	CH_3COOH	calcium hydroxide	$Ca(OH)_2$
carbonic acid	H_2CO_3	magnesium hydroxide	$Mg(OH)_2$
nitric acid	HNO_3	ammonia	NH_3
phosphoric acid	H_3PO_4	sodium hydrogen carbonate/ sodium bicarbonate	$NaHCO_3$

REMEMBER

A strong base is as dangerous as a strong acid.

QUESTION 2

Complete the table of acids and bases.

	NAME	FORMULA	Strong/weak acid or base Eg strong base
2.1	ammonia		
2.2	sulphuric acid		
2.3	nitric acid		
2.4	sodium carbonate		
2.5	sodium hydrogen carbonate		
2.6	hydrochloric acid		
2.7	potassium hydroxide		
2.8	carbonic acid		
2.9	phosphoric acid		
2.10	ethanoic acid / acetic acid		

ACID BASE MODELS

There are a number of theories that identify the characteristics which define a substance as either an acid or a base.

These are:

- Arrhenius Theory
- Bronsted - Lowry Theory
- Lewis or electron pair Theory

We will look at the first two theories here.

ARRHENIUS THEORY (1903)

Swedish chemist Arrhenius was awarded the 1903 Nobel Prize in chemistry for his theory.

He proposed that :

- acids are compounds that can dissociate (break up) in water to yield hydrogen ions H^+
- bases are compounds that can dissociate (break up) in water to yield hydroxide ions OH^-

	ARRHENIUS
ACID	A substance that ionises in water to produce hydrogen ions (H^+)
BASE	A substance that dissociates in water to produce hydroxide ions (OH^-)

They proposed that:

- acids are compounds that can donate a proton (H^+)
- bases are compounds that can accept a proton (H^+)

They also proposed that since water H_2O can both donate and accept a proton, it could act as both an acid or a base and was **amphiprotic.**

It can lose a proton to form a hydroxide ion, OH^-, or accept a proton to form a hydronium ion.

When an acid loses a proton, the remaining species can be a proton acceptor and is called the conjugate base of the that acid.

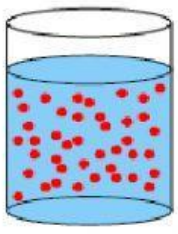
Similarly, when a base accepts a proton, the resulting species can be a proton donor and is called the conjugate acid of that base.

When a water molecule loses a proton to form a hydroxide ion (OH^-), the hydroxide ion can be considered the conjugate base of the acid, water.

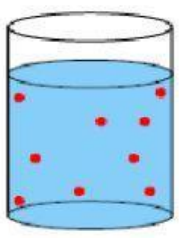
When a water molecule accepts a proton to form a hydronium ion (H_3O^+), the hydronium ion can be considered the conjugate acid of the base, water.

DILUTE vs CONCENTRATED ACIDS AND BASES

Dilution or concentration are not acidic nor basic properties.
A diluted acid contains a lower number of H_3O^+ ions.
Another way of describing it is to say that a diluted acid has a low number of moles of H_3O^+ per dm^3 of solution .



A concentrated solution has a lot of solute molecules (red circles) in the solvent.



A dilute solution has few solute molecules (red circles) in the solvent.

Similarly, a concentrated alkali contains a high number of OH^-

Strong and weak acids can be both concentrated or dilute, depending on how much water is added to them. The same applies to strong and weak bases.

(When you pour a cup of hydrochloric acid into your swimming pool, this is an example of a strong acid being made into a dilute solution.)

IN SUMMARY: Write these definitions into your book

concentrated acid: large amounts of acid dissolved in a small amount of water

dilute acid: small amounts of acid dissolved in a large amount of water

concentrated base: large amount of base dissolved in a small amount of water

dilute base: small amount of base dissolved in a large amount of water