Questions: Acids & bases and pH calculations:

QUESTION (2012:3)

(a) (i) Complete the table below showing the conjugate acids and bases.

Conjugate acid	Conjugate base
HCO_3^-	
H_2O	
	CN^-

(ii) **HPO_4^{2-}(aq)**

Write equations for the reactions of HPO_4^{2-} with water: one where it acts as an acid, and one where it acts as a base.

HPO_4^{2-} acting as	Equation
An acid	$HPO_4^{2-} + H_2O \rightleftharpoons$
A base	$HPO_4^{2-} + H_2O \rightleftharpoons$

(b) A solution contains 9.56×10^{-5} mol L^{-1} of hydroxide ions.

(i) Calculate the concentration of hydronium ions, H_3O^+.

(ii) Is this solution acidic, basic or neutral at 25°C?
Explain your answer.

(c) (i) Calculate the pH of a 0.133 mol L^{-1} solution of hydrochloric acid.

(ii) Calculate the hydroxide ion concentration, $[OH^-]$, of a solution of sodium hydroxide with a pH of 12.8.

(d) Some properties of three aqueous solutions A, B and C, of equal concentration are shown in the table below.

Solution	A	B	C
pH	5.15	11.6	1.05
Electrical conductivity	good	poor	good

The labels of the three solutions have been removed.
It is known that the solutions are NH_3(aq), HCl(aq) and NH_4Cl(aq).
Use the information in the table above to identify each of the three solutions.

Justify the identification of all three solutions.

In your answer you should:

- refer to both pH and electrical conductivity of the solutions
- link your answers to appropriate chemical equations.

Questions: Acids & bases and pH calculations:

QUESTION (2011:3)

(a) (i) Identify one conjugate acid / base pair for the following reaction:

$$NH_4^+ + PO_4^{3-} \rightleftharpoons NH_3 + HPO_4^{2-}$$

(ii) $HSO_4^-(aq)$ is a species that can act as an acid or a base.
Write two equations for reactions of HSO_4^- with water: one equation where it acts as an acid, and one where it acts as a base.

(b) (i) Calculate the pH of a 0.0498 mol L–1 solution of hydrochloric acid.

(ii) Calculate the pH of an oven cleaner containing 0.251 mol L^{-1} sodium hydroxide.

(iii) The pH of a sample of rainwater, near a polluted city, is 4.62. Calculate the hydronium ion concentration, $[H_3O^+]$, and the hydroxide ion concentration, $[OH^-]$, in the rainwater.

(c) Three aqueous solutions, of equal concentration, have the following pH values:

Solution	$HNO_3(aq)$	HCOOH(aq)	KOH(aq)
pH	2.0	2.9	12

Compare and contrast both the strength and electrical conductivity of these aqueous solutions.
Include appropriate equations in your answer.

QUESTION (2010:2)

(a) (i) A beaker contains 0.108 mol L^{-1} hydrochloric acid.
Calculate the concentration of hydronium ions, $[H_3O^+]$, and the concentration of hydroxide ions, $[OH^-]$, in this solution.

(ii) A beaker contains hydrochloric acid with a pH of 1.58.
Calculate the concentration of hydronium ions, $[H_3O^+]$, and the concentration of hydroxide ions, $[OH^-]$, in this solution.

(iii) A beaker contains 0.362 mol L^{-1} sodium hydroxide.
Calculate the concentration of hydronium ions, $[H_3O^+]$, the concentration of hydroxide ions, $[OH^-]$, and the pH of this solution.

(b) The concentration and pH of two acids HA and HB are shown in the table below.

Acid	Concentration / mol L–1	pH
HA	0.00100	3.00
HB	0.0100	3.40

(i) Identify which one of these acids is **weaker**

(ii) Explain the reasons for your choice.
You must include reference to both acids in your answer.

(c) A sample of sodium ethanoate, CH_3COONa, is dissolved in water. The solution is tested and found to be basic. Explain why the solution is basic. Include appropriate equation(s) in your answer.

QUESTION (2009:1)

(a) Complete the equations below to show how each species will react with water to form an acidic solution.

(i) $HCl + H_2O \rightarrow$

(ii) $CH_3COOH + H_2O \rightleftharpoons$

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(b) (i) Determine the $[H_3O^+]$, $[OH^-]$, and pH in each of the following two solutions. $[H_3O^+]$ for HCl has been listed.

0.0376 mol L^{-1} HCl solution

$[H_3O^+]$/mol L^{-1}	$[OH^-]$/mol L^{-1}	pH
0.0376		

2.48×10^{-4} mol L^{-1} NaOH solution

$[H_3O^+]$/mol L^{-1}	$[OH^-]$/mol L^{-1}	pH

(ii) Explain why the concentration of the acid, HCl, is equal to the concentration of the hydronium ion, $[H_3O^+]$

(iii) The concentration of the hydronium ion, H_3O^+, in a 0.0376 mol L^{-1} solution CH_3COOH is less than 0.0376 mol L^{-1}. Explain why the concentration of the hydronium ion is less than 0.0376 mol L^{-1}.

(c) Conductivity of solutions can be described as being high, low, or having no conductivity. Compare and contrast the conductivity of the three solutions shown below.

0.100 mol L^{-1} HCl, 0.100 mol L^{-1} CH_3COOH & 0.100 mol L^{-1} NaOH

QUESTION (2008:3)

Complete the equations below to show how each species will react with water to form an acidic solution.

(a) $NH_4^+(aq) + H_2O \rightleftharpoons$

(b) $HF(aq) + H_2O \rightleftharpoons$

QUESTION (2008:4)

Determine the $[H_3O^+]$, $[OH^-]$ and pH in each of the following solutions.

(a) 0.00112 mol L^{-1} HCl solution.

(b) 3.68×10^{-2} mol L^{-1} NaOH solution.

QUESTION (2008:8)

Aqueous solutions of acids HA and HB both have the same concentration of 0.100 mol L^{-1}. The pH of the solution of acid HA is 3.5 and the pH of the solution of acid HB is 1.8.

(a) (i) Identify which one of these acids is stronger and circle your choice. HA HB

(ii) Discuss the reasons for your choice.

You should include relevant equations in your answer, as well as reference to what is meant by the strength of an acid.

(b) Describe what is observed when the following two tests are carried out on 5 mL samples of the acids HA and HB.

(i) Identical small pieces of magnesium ribbon are placed in each acid.

(ii) Sodium hydroxide solution is slowly added to each acid. The volume of sodium hydroxide solution required to completely react with the acid is measured.

(c) Discuss the observations in (b) (i) and (ii).
Your answer must include reference to:

- similarities and / or differences in the observations of the tests on each acid
- equations for reactions.

QUESTION (2007:1)

(a) The bicarbonate ion, HCO_3^-, can both accept and donate hydrogen ions (protons).
Complete the equations below.

$HCO_3^- + H_2O \rightleftharpoons H_3O^+ +$ Reaction A

$HCO_3^- + H_2O \rightleftharpoons OH^- +$ Reaction B

(b) When sodium bicarbonate, $NaHCO_3$, dissolves in water the solution is basic. Circle Reaction A or Reaction B to show which reaction predominates. Justify your answer.

QUESTION (2007:2)

(a) Give the pH of 0.125 mol L^{-1} HCl.

(b) Calculate the hydroxide ion concentration of NaOH solution at pH 10.2.

(c) Calculate the pH of 0.124 mol L^{-1} NaOH.

QUESTION (2007:7)

Methyl orange can be used as an acid-base indicator. It is pink in solutions with a pH less than 3 and yellow in solutions with a pH greater than 4.

Four beakers are known to contain one each of:

- 0.1 mol L^{-1} HCl
- 0.01 mol L^{-1} HCl
- distilled water
- 0.1 mol L^{-1} NaOH

(a) Complete the following table.

	pH	Colour of methyl orange
0.1 mol L^{-1} HCl		
0.01 mol L^{-1} HCl		
distilled water		
0.1 mol L^{-1} NaOH		

(b) Using only the methyl orange indicator, additional water, test tubes and a measuring cylinder, discuss how a student could identify each of the four solutions.

QUESTION (2006:1)

(a) Complete the table below to show the conjugate acid-base pairs.

Conjugate acid	Conjugate base
NH_4^+	
$H_2PO_4^-$	
	Cl^-
	HSO_4^-

(b) Circle the ion that can act as both an acid and a base. CH_3COO^- HCO_3^-
Justify your choice.

Questions: Acids & bases and pH calculations:

QUESTION (2006:4)

The table below shows the pH of two acids, HA and HB, each with the same concentration. When these acids react with magnesium metal, hydrogen gas (H_2) is produced. Discuss the reactions of both acids, HA and HB, with magnesium metal when the same volume of each acid is used.

Acid	pH
HA	1.00
HB	4.00

In your answer include:

- species in solution
- rate of reaction
- total volume of gas produced.

QUESTION (2006:7)

(a) Complete the table below to show the hydronium ion concentration, hydroxide ion concentration, and pH for the three solutions shown.

$$Kw = 1.00 \times 10^{-14}$$

Solution	$[H_3O^+]$ / mol L^{-1}	$[OH^-]$ / mol L^{-1}	pH
hydrochloric acid (HCl)	0.0720		
sodium hypochlorite (NaOCl)			11.4
hypochlorous acid (HOCl)		2.24×10^{-11}	

(b) Hypochlorous acid is a weak acid. Complete the equation below to show the reaction of hypochlorous acid with water.

$HOCl + H_2O \rightleftharpoons$ _____ + _____

(c) A solution of sodium hypochlorite, NaOCl, is basic. Discuss the above statement, including appropriate chemical equation(s) in your answer.

QUESTION (2005:6)

The concentration and pH of three acids, HA, HB and HC, are shown in the table below.

acid	concentration (mol L^{-1})	pH
HA	0.100	1.00
HB	0.100	2.50
HC	0.00100	3.00

(a) A small piece of magnesium is added to a 20 mL sample of each of the acids. Circle the acid that would be expected to react most rapidly with the magnesium. acid HA acid HB acid HC
Explain why this acid will react the fastest.

(b) Circle the weakest acid. acid HA acid HB acid HC
Explain why this acid is the weakest.

Questions: Acids & bases and pH calculations:

QUESTION (2005:7)

Complete the following table showing hydronium ion concentration, hydroxide ion concentration and pH for some solutions. $K_w = 1.00 \times 10^{-14}$

Solution	$[H_3O^+]$	$[OH^-]$	pH
1	0.0350		
2			10.8
3		5.66×10^{-6}	

QUESTION (2005:8)

A solution of sodium ethanoate ($NaCH_3COO$) is tested and found to have a pH of 8.50.
Discuss why the pH of the solution is greater than 7. Include appropriate equation(s) in your answer.

QUESTION ONE (2004:1)

Chickens make egg shell, $CaCO_3$, using carbon dioxide gas from the air. The carbon dioxide forms carbonic acid (H_2CO_3), which then reacts to form the carbonate ions (CO_3^{2-}) needed to make egg shell. Two equations showing part of this process are given below.

Equation 1: $H_2CO_3(aq) + H_2O(l) \rightleftharpoons HCO_3^-(aq) + H_3O^+(aq)$

Equation 2: $HCO_3^-(aq) + H_2O(l) \rightleftharpoons CO_3^{2-}(aq) + H_3O^+(aq)$

(a) Identify three conjugate acid-base pairs in the equations above.

(b) HCO_3^- can act as both an acid and a base. Specify which equation above (1 or 2) shows HCO_3^- acting as an acid. Give a reason for your answer.

QUESTION (2004:3)

Two acids of the same concentration, hydrochloric acid (HCl) and propanoic acid (CH_3CH_2COOH), have properties as shown below:

Property	Hydrochloric acid (0.100 mol L^{-1})	Propanoic acid (0.100 mol L^{-1})
Relative conductivity of solution	High	Low
pH of solution	1.00	2.93

(a) Complete the following equations to show the reaction of both hydrochloric acid and propanoic acid with water.

$HCl + H_2O \rightarrow$

$CH_3CH_2COOH + H_2O \rightleftharpoons$

(b) Consider the properties described in the table above. Explain the differences in the conductivity and pH of the two acids. In your explanation include reference to the species present in each solution.

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QUESTION (2004:6)

(a) The table below shows four different solutions. Each solution contains both hydronium ions (H_3O^+) and hydroxide ions (OH^-). Complete the table, showing the relative concentrations of these two ions in solution, by placing H_3O^+ ions and OH^- ions in the appropriate box. The first one has been done for you.

Solution	Concentration of H_3O^+ and OH^- in solution	
	Greater than 1×10^{-7} mol L^{-1}	Less than 1×10^{-7} mol L^{-1}
Na_2CO_3 0.100 mol L^{-1}	OH^-	H_3O^+
HNO_3 0.100 mol L^{-1}		
NaOH 0.100 mol L^{-1}		
NH_4Cl 0.100 mol L^{-1}		

(b) Calculate the pH of a solution with a hydronium ion concentration, $[H_3O^+]$, of 0.0350 mol L^{-1}. State your answer to 3 significant figures.

(c) If a solution of sodium hydrogen carbonate has a pH of 9.20, calculate the concentration of hydroxide ions, $[OH^-]$, present in the solution. State your answer to 3 significant figures.
$K_w = 1.00 \times 10^{-14}$