25.1 ACIDS AND BASES- WORKSHEET II

Buffer solution

1. Define buffer solution.

   .....

   ..... [1or 2]

2. Identify one inorganic ion that acts as a buffer in blood.

   ..... [1]

3. Suggest a substance that could be added to aqueous ethanoic acid to form a buffer solution.
   Explain your answer.

   .....

   .....

   ..... [1]

4. An aqueous solution of butanoic acid can be used to make a buffer solution.
   Suggest one organic compound and one inorganic compound that can be added to two different samples of aqueous butanoic acid to produce buffer solutions.

   organic compound .....

   inorganic compound ..... [1]

5. Disodium phosphate, $(Na^+)_2(HPO_4^{2-})$, reacts with an acid to form monosodium phosphate, $Na^+(H_2PO_4^-)$.
   Write two equations to show how a mixture of $(Na^+)_2(HPO_4^{2-})$ and $Na^+(H_2PO_4^-)$ can act as a buffer solution.

   equation1 .....

   equation 2 .....[2]

6. Some fertilisers contain calcium dihydrogenphosphate, $Ca(H_2PO_4)_2$.
   An aqueous solution containing dihydrogenphosphate ions, $H_2PO_4^-$, can act as a buffer solution.
   Write two equations to show how $H_2PO_4^-$ ions can act as a buffer.

   equation 1 .....

   equation 2 ..... [2]

7. Buffer solutions are used to regulate pH.
   Write **two** equations to describe how a solution containing $HC_2O_4^-$ ions acts as a buffer solution when small amounts of acid or alkali are added.

   .....

   ..... [2]

8. The buffer system in seawater contains a mixture of HCO_3^- and H_2CO_3.
equilibrium 5 $H_2CO_3 + H_2O \rightarrow HCO_3^- + H_3O^+$

Construct two equations to show how equilibrium 5 acts as a buffer solution.

.....

..... [2]

9. Benzoic acid, C_6H_5COOH, is a weak acid. The Ka of benzoic acid is 6.31×10^{-5} mol dm^{-3} at 298 K.
A 1.00 dm^3 buffer solution is made at 298 K containing 1.00 g of C_6H_5COOH and a slightly greater mass of sodium benzoate, $C_6H_5COO^-Na^+$.
This buffer solution has a pH of 4.15.
Write equations to show how this solution acts as a buffer solution when the named substances are added to it:
(i) dilute aqueous sodium hydroxide

..... [1]

(ii) dilute aqueous nitric acid.

……..... [1]

(iii) Calculate the H^+ concentration and the C_6H_5COOH concentration in the buffer solution described. Use the expression for the K_a of C_6H_5COOH to calculate the concentration of $C_6H_5COO^-Na^+$ in the buffer solution.
Show your working and give each answer to a minimum of three significant figures.

$[H^+]$ = ... mol dm^{-3}

$[C_6H_5COOH]$ = ... mol dm^{-3}

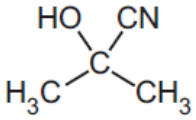
$[C_6H_5COO^-Na^+]$ = ... mol dm^{-3} [3]

10. A buffer solution containing a mixture of CH_3COOH and CH_3COONa is prepared as follows.
A solution of 600 cm^3 of CH_3COOH is mixed with 400 cm^3 of 0.125 mol dm^{-3} CH_3COONa.
The buffer solution has pH 5.70. The K_a of CH_3COOH is 1.78×10^{-5} mol dm^{-3}.
Calculate the initial concentration, in mol dm^{-3}, of CH_3COOH used.

Concentration of CH_3COOH = ... mol dm^{-3} [3]

11. Propanone also reacts with acidified cyanide ions to form the hydroxynitrile compound B, as shown by reaction 2.

reaction 2 $CH_3COCH_3 + H^+ + CN^-$ ⟶ **B**



Carboxylic acid C, $C_4H_8O_3$, forms when B is hydrolysed under hot acidic conditions.
(i) Draw the structure of C. [1]

(ii) The pKa of C is 3.95. Calculate the pH of a 0.500 mol dm^{-3} solution of C.
Show your working.

pH = ...(ans = 2.13) ..... [2]

(iii) C can be used to form buffer solution D.
Buffer solution D is made when 20.0 cm^3 of 1.00 mol dm^{-3} NaOH(aq) is added to 100 cm^3 of a 0.500 mol dm^{-3} solution of C.
The pKa of C is 3.95.
Calculate the pH of buffer solution D.
Show your working.

pH = ...(ans=3.77)..... [3]

12. (a) A buffer solution of pH 5.00 is produced by adding sodium propanoate to 5.00 g of propanoic acid in 100 cm^3 of distilled water.
Calculate the mass of sodium propanoate that must be used to produce this buffer solution.
The Ka of propanoic acid is 1.35×10^{-5} mol dm^{-3}.
[Mr: propanoic acid, 74.0; sodium propanoate, 96.0]

mass of sodium propanoate = ... g [3]

(b) Some dilute sulfuric acid is mixed with a small sample of the buffer solution described in (a). The final pH of the mixture is close to 1.
Explain this observation.

.....

.....

.....

..... [2]

13. A 10.0 cm^3 sample of the buffer solution is mixed with 10.0 cm^3 of 1.00 mol dm^{-3} KOH. Both solutions are at 298 K. A reaction is allowed to occur without stirring.
Two observations are recorded:
- the temperature, after the reaction is complete, is fractionally above 298 K
- the pH, after the reaction, is greater than 13.

Explain these two observations.

…….....

…….....

……..... [2]

14. The numerical value of the *K*a of HBrO is 2.00×10^{-9}.
X is a solution of HBrO which contains 4.00×10^{-3} mol of HBrO in 100 cm^3 of solution. In this solution, the following equilibrium is established, in which there are two conjugate acid-base pairs.
$HBrO + H_2O \rightleftharpoons BrO^- + H_3O^+$
(i) Define conjugate acid-base pair.

.....

..... [1]

(ii) Identify the two conjugate acid-base pairs shown in the equation above. [1]

pair one ....
acid base

pair two ....
acid base

Calculate the pH of solution **X**. Show all your working.

pH = ... [2]

(iv) A solution containing 2.00×10^{-3} mol of NaOH is added to solution **X**. A buffer solution is formed.
Calculate the pH of this buffer solution.

pH = ... [1]

15. The ionic product, Kw, for D_2O has a value of 1.35×10^{-15} mol^2 dm^{-6} at 298 K.
(i) Write the expression for the Kw of D_2O.

Kw = [1]

(ii) Calculate the pH of pure, neutral D_2O at 298 K.
Assume $[D^+]$ is equivalent to $[H^+]$ for pH calculations.

pH = ... [2]

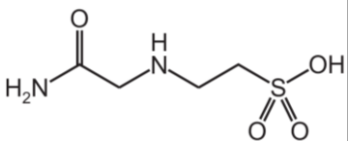
16. The buffer system in seawater contains a mixture of HCO_3^- and H_2CO_3.
equilibrium 5 $H_2CO_3 + H_2O \rightarrow HCO_3^- + H_3O^+$

The $[HCO_3^-] / [H_2CO_3]$ ratio in a sample of seawater is 14.1.
Calculate the pH of this sample.
[pKa: H_2CO_3, 6.35]

pH= .....(ans = 7.5)..... [3]

17. The weak acid ACES is a compound that can be used to make a buffer solution for electrophoresis experiments.

ACES



The anion of the sodium salt of ACES, $C_4H_9N_2O_4SNa$, is a strong base.
A buffer solution is prepared by the following steps.
- 3.50 g of $C_4H_9N_2O_4SNa$ is dissolved in 100 cm3 of distilled water.
- 50.0 cm^3 of 0.200 mol dm^{-3} dilute hydrochloric acid is added to the solution.
- The resulting mixture is transferred to a 250.0 cm^3 volumetric flask, and the solution is made up to the mark.

$C_4H_9N_2O_4SNa$ reacts with HCl with a 1 : 1 stoichiometry.
The pKa of ACES is 6.88 at 298 K.
Calculate the pH of the buffer solution formed at 298 K.
[Mr: $C_4H_9N_2O_4SNa$, 204.1]

pH = ... [4]

18. In a third experiment, the pH of the mixture of metal ions is kept constant using a buffer solution.
The student prepares the buffer solution by mixing 20.0 cm^3 of 0.150 mol dm^{-3} KOH(aq) and 50.0 cm^3 of 0.100 mol dm^{-3} $C_8H_5O_4K$(aq).
$C_8H_5O_4K$ is a weak carboxylic acid that has p*K*a = 5.40.

$C_8H_5O_4K$

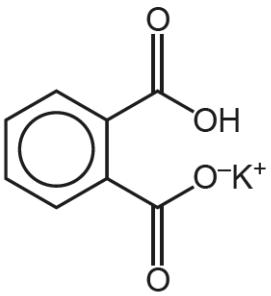


Fig. 6.2

(i) Complete the equation for the reaction of $C_8H_5O_4K$(aq) with KOH(aq).

$C_8H_5O_4K$ + ... [1]

(ii) Calculate the pH of the buffer solution. Show all your working.

`

pH = ... [4]

K_{sp}

19. A. Write equilibrium expressions for the solubility products of the following:
a. $Fe(OH)_2$ c. Fe_2S_3 b. $Al(OH)_3$

B. State the units of the solubility product for each of the compounds in part **A**.

20. The solubility of aluminium hydroxide, $Al(OH)_3$, in water is 2.47×10^{-9} mol dm^{-3}.
(i) Give the expression for the solubility product, Ksp, of aluminium hydroxide.

Ksp = [1]

(ii) Calculate the numerical value of the Ksp of aluminium hydroxide. Include the units of Ksp in your answer.

Ksp = ... units = ... [3]

21. Nickel(II) iodate(V), $Ni(IO_3)_2$, is sparingly soluble in water. The concentration of its saturated solution is 2.30×10^{-2} mol dm^{-3} at 298 K.

(a) Complete the expression for the solubility product, Ksp, of $Ni(IO_3)_2$. Include the units.

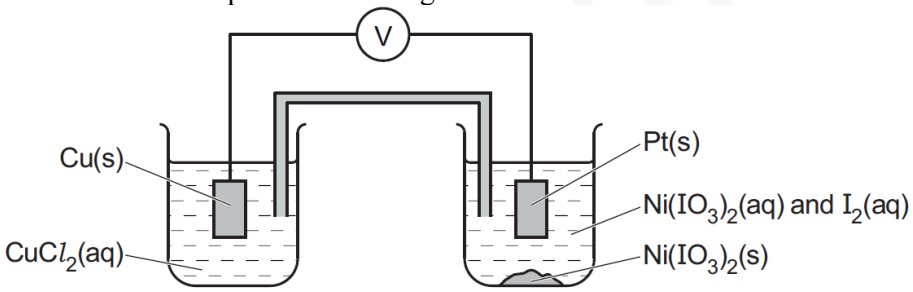
K_{sp} =

units = ... [2]

(b) Calculate the numerical value for K_{sp} of $Ni(IO_3)_2$ at 298 K.

Ksp = ... [1]

(c) An electrochemical cell is set up as shown in Fig.



The relevant standard electrode potentials, $E^{\ominus}$, for this electrochemical cell are shown.

$IO_3^-(aq) + 6H^+(aq) + 5e^- \rightleftharpoons 1/2\ I_2(aq) + 3H_2O(l)$ $E^{\ominus} = +1.19$ V

$Cu^{2+}(aq) + 2e- \rightleftharpoons Cu(s)$ $E^{\ominus} = +0.34$ V

(i) Use this information to calculate the value of $E^{\ominus}_{cell}$. State which electrode is positive.

$E^{\ominus}_{cell}$ = ... positive electrode is ..... [1]

(ii) Suggest how the measured Ecell of this cell compares to the E^{o}cell under standard conditions. Explain your answer.

.....

..... [1]

(iii) Complete Table 3.1 by placing one tick (3) to indicate how the Ecell of this cell changes when a small amount of $NiSO_4(aq)$ is added to the beaker containing $Ni(IO_3)_2(aq)$ and $I_2(aq)$ in Fig. 3.1.
Explain your answer.

Table 3.1

change in E_{cell}		
less positive	no change	more positive

.....

.....

.....[2]

22. The solubility of iron(II) hydroxide, $Fe(OH)_2$, is 5.85×10^{-6} mol dm^{-3} at 298 K.

(i) Write the expression for the solubility product, K_{sp}, of $Fe(OH)_2$.

*K*sp = [1]

(ii) Calculate the value of *K*sp of $Fe(OH)_2$. Include its units.

*K*sp = ... units = ... [2]

23. The solubility of calcium phosphate, $Ca_3(PO_4)_2$, is 1.14×10^{-7} mol dm^{-3} at 25 °C.
The expression for the solubility product, Ksp, of $Ca_3(PO_4)_2$is shown.
$Ksp = [Ca^{2+}]^3[PO_4^{3-}]^2$
Calculate the value of Ksp for $Ca_3(PO_4)_2$. Include units.

Ksp = ... units .....[3]

24. Calcium hydroxide is slightly soluble in water.
(i) Write an equation to show the dissociation of calcium hydroxide, $Ca(OH)_2(s)$, in aqueous solution. Include state symbols.

..... [1]

(ii) Calculate the solubility, in mol dm^{-3}, of $Ca(OH)_2$.
[Ksp: $Ca(OH)_2$, 5.02×10^{-6} mol^3 dm^{-9}]

solubility = ... mol dm^{-3} [2]

25. The solubility product of manganese(II) hydroxide, $Mn(OH)_2$, in water is 1.1×10^{-11} mol^3 dm^{-9} at 298 K.
Calculate the solubility of $Mn(OH)_2$ in water at 298 K.

solubility = ... mol dm^{-3} [2]

26. Silver sulfite, $Ag_2SO_3(s)$, is sparingly soluble in water.
(i) Give an expression for the solubility product, Ksp, of Ag_2SO_3.

Ksp = [1]

(ii) Calculate the equilibrium concentration of Ag^+ in a saturated solution of Ag_2SO_3 at 298 K.
[Ksp: Ag_2SO_3, 1.50×10^{-14} mol^3 dm^{-9} at 298 K]

$[Ag^+]$ = ... mol dm^{-3} [1]

27. Solid PbI_2 forms when KI(aq) is mixed with $Pb^{2+}(aq)$ ions.
The solubility product, K_{sp}, of PbI_2 is 7.1×10^{-9} mol^3 dm^{-9} at 25 °C.
Calculate the solubility, in mol dm^{-3}, of $PbI_2(s)$.

solubility of $PbI_2(s)$ = ...mol dm^{-3} [2]

28. An orange precipitate of HgI_2 forms when Hg^{2+} ions are added to KI(aq).
The solubility of HgI_2 at 25 ° C is 1.00×10^{-7} g dm^{-3}.
Calculate the solubility product, *K*sp, of HgI_2.
Include units in your answer.
[*M*r: HgI_2, 454.4]

value of *K*sp = ...units = ...[3]

29. $Pb(IO_3)_2$ is only sparingly soluble in water at 25 ° C.
The solubility product, *K*sp, of $Pb(IO_3)_2$ is 3.69×10^{-13} mol^3 dm^{-9} at 25 ° C.
(i) Write an expression for the solubility product of $Pb(IO_3)_2$.

*K*sp = [1]

(ii) Calculate the solubility, in mol dm^{-3}, of $Pb(IO_3)_2$ at 25 ° C.

solubility = ... mol dm^{-3} [2]

30. The solubility product, K_{sp}, of $BaSO_4$ is 1.08×10^{-10} mol^2 dm^{-6} at 298 K.
Calculate the solubility of $BaSO_4$ in g per 100 cm^3 of solution.

solubility of $BaSO_4$ = ...(ans =2.43 x 10^{-4})..... g per 100 cm^3 of solution [2]

31. Chromium(III) hydroxide, $Cr(OH)_3$, is only slightly soluble in water. The value of the solubility product, Ksp, of $Cr(OH)_3$ is 1.0×10^{-33} at 298 K.
(i) Complete the expression for Ksp of $Cr(OH)_3$. Include the units.

Ksp =

units = ... [2]

(ii) Calculate the solubility, in g dm^{-3}, of $Cr(OH)_3$ in pure water at 298 K.
Show your working.

solubility = ... g dm^{-3} [3]

32. Table 2.2 lists values of solubility products, **K**$_{sp}$, of some Group 2 carbonates.

Table 2.2

	solubility product in water at 298 K, **K**$_{sp}$ / mol^2 dm^{-6}
$MgCO_3$	1.0×10^{-5}
$CaCO_3$	5.0×10^{-9}
$SrCO_3$	1.1×10^{-10}

(i) Deduce the trend in the solubility of the Group 2 carbonates down the group. Justify your answer using the data given. [1]

(ii) Use the data in Table 2.2 to calculate the solubility of $MgCO_3$ in water at 298 K, in g dm^{-3}. Show your working.

solubility of $MgCO_3$ = ... g dm^{-3} [2]

33. (a) Compound E is the hydroxide of a Group 2 element. Compound E is a strong alkali.
2.63 g of E is dissolved in water to make 250 cm^3 of solution F. Solution F has a pH of 13.09 at 298 K.
(i) Show that the concentration of hydroxide ions in solution F is 0.123 mol dm^{-3}. [2]

(ii) Explain why the concentration of compound E in solution F is 0.0615 mol dm^{-3}.

…….....

…….....[1]

(iii) Use the concentration given in (ii) to identify compound E.

compound E ..... [1]

(b) Compound E is much more soluble than magnesium hydroxide.
A saturated solution of magnesium hydroxide in water has a concentration of 1.40×10^{-4} mol dm^{-3} at 298 K.
Calculate the solubility product, Ksp, of magnesium hydroxide. Include units.

Ksp = ... units ..... [3]

(c) Explain why compound E is much more soluble than magnesium hydroxide.
(Refer to Chapter 23.2 Enthalpy of solution and hydration)

……

……

……

……

……

……

……

…… [3]

34. Calculate the value of the solubility product, *K*sp, of magnesium hydroxide at 25 ° C.

*K*sp = ...[2]

The common ion effect

35. Calcium hydroxide is slightly soluble in water
Suggest how the solubility of $Ca(OH)_2$ in aqueous NaOH compares to its solubility in water.
Explain your reasoning.

……

……

…… [1]

36. The solubility of calcium phosphate, $Ca_3(PO_4)_2$, is 1.14×10^{-7} mol dm^{-3} at 25 °C.
Some solid sodium phosphate is added to a saturated solution of $Ca_3(PO_4)_2$.
Predict the effect, if any, on the solubility of $Ca_3(PO_4)_2$.
Explain your answer.

.....

.....

..... [1]

37. (i) Write an equation to show the equilibrium for the solubility product of $MgCO_3$. Include state symbols. [1]

(ii) With reference to your equation in **(i)**, suggest what is observed when a few cm^3 of concentrated $Na_2CO_3(aq)$ are added to a saturated solution of $MgCO_3$. Explain your answer. [2]

38. An aqueous solution of lead(II) nitrate is mixed with an aqueous solution of sodium iodide. A yellow precipitate of lead(II) iodide is formed and is filtered out, leaving solution **X**.
The concentration of Pb^{2+} in solution **X** is 5.68×10^{-3} mol dm^{-3}.
The concentration of I^- in solution **X** is 4.20×10^{-4} mol dm^{-3}.
(i) Use these data to calculate a value for the solubility product, *K*sp, of lead(II) iodide.
State the units of *K*sp.

*K*sp = ...units = ... [2]

(ii) Potassium iodide is very soluble in water.
Describe and explain what is seen if a few drops of saturated potassium iodide solution are added to a portion of solution **X**.

.....

.....

..... [2]

39. Magnesium benzoate, $Mg(C_6H_5COO)_2$, has a solubility in water of less than 1.00 g dm^{-3} at 298 K.
$Ksp = [Mg^{2+}][C_6H_5COO^-]^2 = 1.76 \times 10^{-7}$ at 298 K
(i) Calculate the solubility of $Mg(C_6H_5COO)_2$ in water at 298 K. Give your answer in g dm^{-3}.
Show your working.
[Mr: $Mg(C_6H_5COO)_2$, 266.3]

solubility = ... g dm^{-3} [2]

(ii) An excess of $Mg(C_6H_5COO)_2$ is added to a sample of 0.50 mol dm^{-3} $MgSO_4$ at 298 K.
State whether the equilibrium concentration of $Mg(C_6H_5COO)_2$ is higher than, the same as, or lower than your answer to (i). Explain your answer.

The concentration is ..... the concentration in (i).

explanation .....

……..... [1]

40. Calcium iodate(V), $Ca(IO_3)_2$, is sparingly soluble in water.
The concentration of its saturated solution is 5.6×10^{-3} mol dm^{-3} at 298 K.
(i) Write an expression for the solubility product, Ksp, of $Ca(IO_3)_2$, and state its units.

Ksp =……units = ... [2]

(ii) Calculate the numerical value for Ksp $Ca(IO_3)_2$ at 298 K.

Ksp = ... [1]

(iii) When a few cm^3 of concentrated $Ca(NO_3)_2(aq)$ is added to a saturated solution of $Ca(IO_3)_2$ a white precipitate forms.
Identify the white precipitate and give an explanation for this observation.

.....

.....

..... [2]

41. Chromium(III) hydroxide, $Cr(OH)_3$, is only slightly soluble in water. The value of the solubility product, Ksp, of $Cr(OH)_3$ is 1.0×10^{-33} at 298 K.
(iii) $Cr(OH)_3$ is less soluble in 0.100 mol dm^{-3} NaOH than it is in pure water.
Explain this observation.

.....

..... [1]

42. Silver carbonate, Ag_2CO_3, is sparingly soluble in water. The numerical value of the solubility product, Ksp, for silver carbonate is 6.3×10^{-12} at 25 ° C.
(i) Write an expression for the solubility product, Ksp, of Ag_2CO_3, and state its units.

Ksp =

units = ... [2]

(ii) Calculate the equilibrium concentration of Ag^+ in a saturated solution of Ag_2CO_3 at 25 ° C.

$[Ag^+]$ = ... mol dm^{-3} [1]

(iii) Solid Ag_2CO_3 is stirred at 25 ° C with 0.050 mol dm^{-3} $AgNO_3$ until no more Ag_2CO_3 dissolves.
Calculate the concentration of carbonate ions, $[CO_3^{2-}]$, in this solution.

$[CO_3^{2-}]$ = ... mol dm^{-3} [1]

43. The value of the solubility product, *K*sp, of iron(III) hydroxide, $Fe(OH)_3$, is given by the following expression.
*K*sp = $[Fe^{3+}][OH^-]^3 = 2.0 \times 10^{-39}$ mol^4 dm^{-12}
(i) Calculate the solubility of $Fe(OH)_3$ in water.

solubility = ... mol dm^{-3} [1]

(ii) Calculate the solubility of $Fe(OH)_3$ in 0.010 mol dm^{-3} barium hydroxide, $Ba(OH)_2$(aq).

solubility = ... mol dm^{-3} [2]

(iii) $Fe(OH)_3$ is less soluble in $Ba(OH)_2$(aq) than it is in pure water.
Name this effect.

..... [1]

Calculations involving titrations

44. Iodised salt is sodium chloride mixed with a small amount of sodium iodate(V), $NaIO_3$.

●● 50.00 g of iodised salt is dissolved in distilled water, and the solution is made up to 250 cm^3 in a volumetric flask with distilled water.

●● 50.0 cm^3 of this solution is pipetted into an excess of aqueous acidified potassium iodide.

$IO_3^- + 5I^- + 6H^+ \rightarrow 3I_2 + 3H_2O$

●● The iodine produced requires 12.40 cm^3 of 0.00200 mol dm^{-3} aqueous sodium thiosulfate solution for complete reaction.

$I_2 + 2S_2O_3^{2-} \rightarrow 2I^- + S_4O_6^{2-}$

Calculate the mass of sodium iodate(V) present in 50.00 g of iodised salt.

mass of $NaIO_3$ = ... g [3]

45. Acidified manganate(VII) ions, MnO_4^-, can be used to analyze solutions containing nitrite ions, NO_2^-, by titration.

X is a solution of $NaNO_2$.

250.0 cm^3 of X is added to 50.0 cm^3 of 0.125 mol dm^{-3} acidified $MnO_4^-(aq)$. The $MnO_4^-(aq)$ ions are in excess; all the NO_2^- ions are oxidised in the reaction.

The unreacted $MnO_4^-(aq)$ required 22.50 cm^3 of 0.0400 mol dm^{-3} $Fe^{2+}(aq)$ to reach the end-point.

The relevant half-equations are shown.

$NO_2^- + H_2O \rightleftharpoons NO_3^- + 2H^+ + 2e^-$

$MnO_4^- + 8H+ + 5e^- \rightleftharpoons Mn^{2+} + 4H_2O$

$Fe^{2+} \rightleftharpoons Fe^{3+} + e^-$

Calculate the concentration, in mol dm^{-3}, of $NaNO_2$ in X.

concentration of $NaNO_2$ in X = ... mol dm^{-3} [3]

46. Potassium sulfite, K_2SO_3, is used as a food additive.
The concentration of sulfite ions, SO_3^{2-}, can be determined by titration using aqueous acidified manganate(VII) ions, MnO_4^-.
• A 250 cm^3 solution contains 3.40 g of impure K_2SO_3.
• 25.0 cm^3 of this solution requires 22.40 cm^3 of 0.0250 mol dm^{-3} acidified MnO_4^- to reach the end-point.
All the SO_3^{2-} ions are oxidised. None of the other species in the impure K_2SO_3 are oxidised.
The reaction occurs as shown by the two half-equations.

$H_2O + SO_3^{2-} \rightleftharpoons SO_4^{2-} + 2H+ + 2e^-$
$MnO_4^- + 8H^+ + 5e- \rightleftharpoons Mn^{2+} + 4H_2O$

(i) Give the ionic equation for the reaction between SO_3^{2-} and acidified MnO_4^-.

……..... [1]

(ii) Calculate the percentage purity of the sample of K_2SO_3.
Show your working.

percentage purity of K_2SO_3 = ... [3]

47. Hydrated compound J, $K_3Fe(C_2O_4)_3 \cdot xH_2O$, contains the green complex ion $[Fe(C_2O_4)_3]^{3-}$.
The value of x can be determined by titration of a sample of J with acidified MnO_4^- ions.
MnO_4^- ions oxidise $C_2O_4^{2-}$ ions in acidic conditions.

$$2MnO_4^- + 5C_2O_4^{2-} + 16H^+ \rightarrow 2Mn^{2+} + 10CO_2 + 8H_2O$$

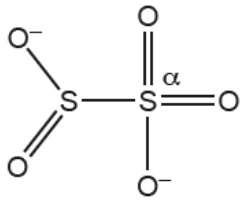
A student prepares a solution containing 0.100 g of J.
The student titrates this solution with 0.0200 mol dm^{-3} acidified $KMnO_4(aq)$. The titre obtained is 12.20 cm^3.
Assume all of the $C_2O_4^{2-}$ ions are oxidised.
Calculate the value of x in $K_3Fe(C_2O_4)_3 \cdot xH_2O$.
Give your answer to the nearest whole number. Show your working.
[Mr: $K_3Fe(C_2O_4)_3$, 437.1]

x = ... [4]

48. When a solution of HClO(aq) is heated, chloric(V) acid and a strong acid not containing oxygen are formed as the only products.
Write an equation for this reaction.

……..... [1]

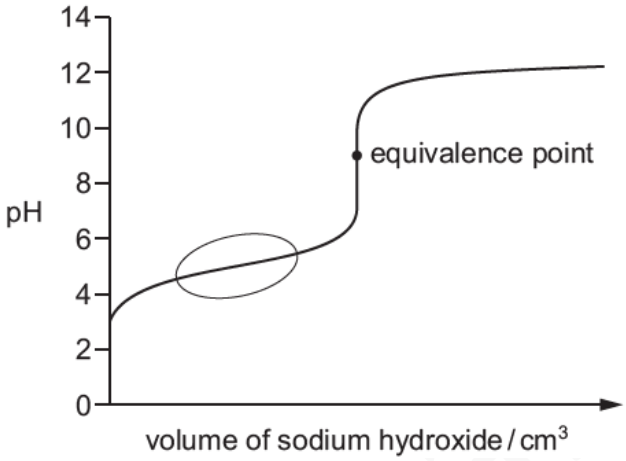
49. Potassium disulfite, $K_2S_2O_5$, is another food additive. The disulfite ion, $S_2O_5^{2-}$, has the displayed formula shown in Fig. 1.2.



Deduce the geometry (shape) around the S(α) atom in $S_2O_5^{2-}$.

geometry around S(α) ..... [1]

50. The sketch graph for the titration of ethanoic acid, CH_3CO_2H, with sodium hydroxide is shown.



(i) In the region circled on the graph, identify the **two** organic species that are present in the solution. Explain why the pH of the mixture only changes slowly and gradually in this region when sodium hydroxide is being added.

two species present ....

.....

.....

.....

..... [3]

(ii) The equivalence point in this acid-base titration is where the two solutions have been mixed in exactly equal molar proportion.
Suggest why the pH is greater than 7 at the equivalence point in this titration.

.....

.....

.....

..... [1]

(b) An impure sample of ammonium vanadate(V), NH_4VO_3, with mass 0.150 g, is dissolved in an excess of dilute acid.

In this solution, all vanadium is present as $VO2^+$ ions. An excess of zinc powder is added to the solution, and all the VO2+ ions are reduced to V^{2+} ions. The mixture is filtered to remove any remaining zinc powder.

$VO2^+ + 4H^+ + 3e– \rightarrow V^{2+} + 2H_2O$

When the resulting solution is titrated, 20.10 cm^3 of 0.0250 mol $dm^{–3}$ acidified $MnO_4–$ oxidises all V^{2+} ions back to $VO2^+$ ions.

$MnO_4– + 8H^+ + 5e– Mn^{2+} + 4H_2O$

Calculate the percentage by mass of NH_4VO_3 in the 0.150 g impure sample of NH_4VO_3.

Give your answer to **three** significant figures.

[*Mr*: NH_4VO_3, 116.9]

percentage by mass of NH_4VO_3 = ... % [3]

***... ***