# Analytical chemistry year 12

Name _____

1) Which one of the following equations represents a redox reaction?
   a) $4Fe(s) + 3O_2(g) \Rightarrow 2\ Fe_2O_3(s)$
   b) $AgNO_3(aq) + KI(aq) \Rightarrow AgI(s) + KNO_3(aq)$
   c) $HCl(aq) + H_2O(l) \Rightarrow H_3O^+(aq) + Cl^-(aq)$
   d) $CO_2(aq) + H_2O(l) \Rightarrow H_2CO_3(aq)$

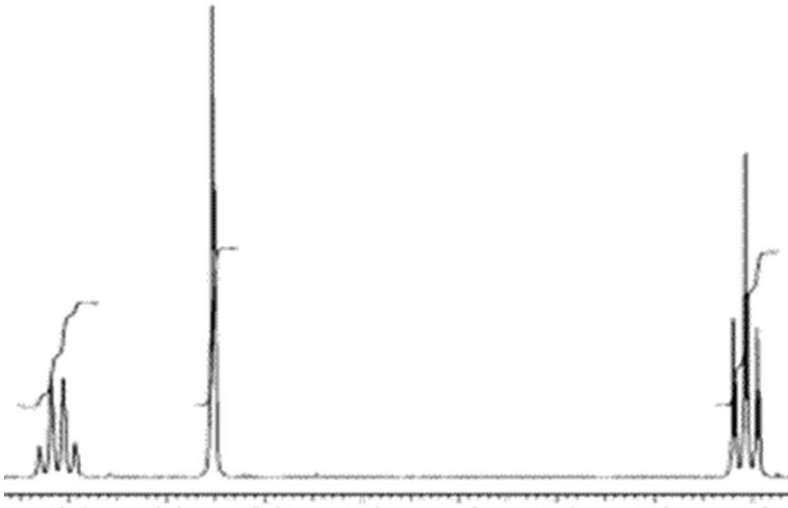
   *a) Is the only reaction where one species is oxidised while the other is reduced. Fe goes from an oxidation state of 0 to an oxidation state of +3 while O goes from an oxidation state of 0 to -2.*

2) Give a reason for your choice in question 1) above.

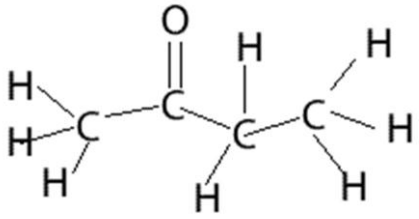
3) Describe the difference in the $^1H$ NMR spectrum of $ClCH_2CH_2Cl$ and $BrCH_2CH_2Cl$

   *$^1H$ NMR spectrum of $ClCH_2CH_2Cl$ will have one singlet as all H's are in the same chemical environment while the $^1H$ NMR spectrum of $BrCH_2CH_2Cl$ will have two sets of triplets because the neighbouring $CH_2$ groups are in different chemical environments.*

4) A compound has the following percentage composition, by mass.
   And its $^1H$ NMR is shown on the right.
   66.67%C, 11.11%H, 22.22%O
   a) Calculate the empirical formula.



b) Draw a possible structure for this molecule.



2+2 = 4 marks

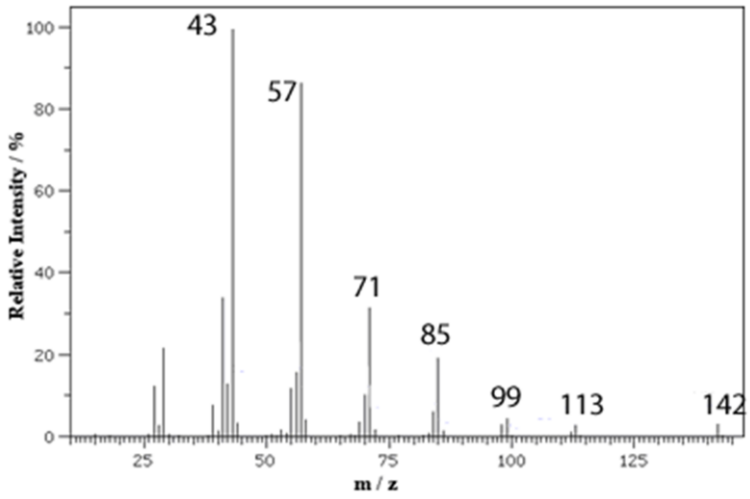
5) A hydrocarbon, with empirical formula CH was analysed in a mass spectrometer. Its mass spectrum is shown below.

a) What is the molar mass of the molecule in g/mol
*142*

b) What is the molecular formula of the compound?
$C_{10}H_{22}$

c) Give a possible formula for the fragment at m/z 99.
$C_7H_{15}^+$

d) Give two possible formulae for the fragment at m/z 71
$C_5H_{11}^+$ *or* $C_{10}H_{22}^{2+}$




6) Jonathon analysed a sample of vinegar for its acetic acid content. Using a 25mL pipette he took a 25.00 mL sample of vinegar stock solution and placed it in a 250 mL volumetric flask. Distilled water was then added to the mark. A 20.00 mL sample was taken from the volumetric flask and placed in a 100mL conical flask. The sample in the conical was titrated against a 0.100 M NaOH solution. A titre of 17.85 mL was needed to reach the end point.

a) Stephen also conducted the same investigation. However he rinsed his conical flask with distilled water. Would his result be higher, lower or the same as Jonathon's? Explain
*No change. Water in the conical flask does not change the amount of acetic acid present in the 20.00mL sample taken from the volumetric falsk.*

b) Stephen conducted the investigation for a second time. This time he rinsed his burette with distilled water. Would his result be higher, lower or the same as Jonathon's? Explain

*Higher. Since the NaOH in the burette is diluted a greater volume needs to be dispensed to give the same mol of NaOH to react with the acetic acid in 20.00mL of diluted vinegar.*

c) Acetic acid is a monoprotic acid ($CH_3COOH$). Write a balanced chemical equation for the reaction between acetic acid and NaOH.

*$NaOH(aq) + CH_3COOH(aq) => NaCH_3COO(aq) + H_2O(l)$*

d) Calculate the mol of acetic acid present in the 20.00mL sample placed in the conical flask.

$n_{NaOH}$ = C X V

⇨ *n = 0.100 X 0.01785 = 0.00179 mol.*

*Since NaOH reacts with acetic acid in a 1:1 ratio*

⇨ *$n_{acetic\ acid}$ = 0.00179*

e) Calculate the concentration of acetic acid in the volumetric flask in mol/L.

*Since the 20.00mL sample placed in the conical flask came from the volumetric flask its concentration is the same as the solution in the volumetric flask.*

*C = n/V*

*=>C = 0.00179/0.0200 =0.0895M*

f) Calculate the concentration of acetic acid, in mol/L, found in the stock solution to the right number of significant figures.

*Calculate the mol of acetic acid in the volumetric flask.*

*$n_{acetic\ acid}$ = C X V = 0.0895 X 0.250 = 0.0224*

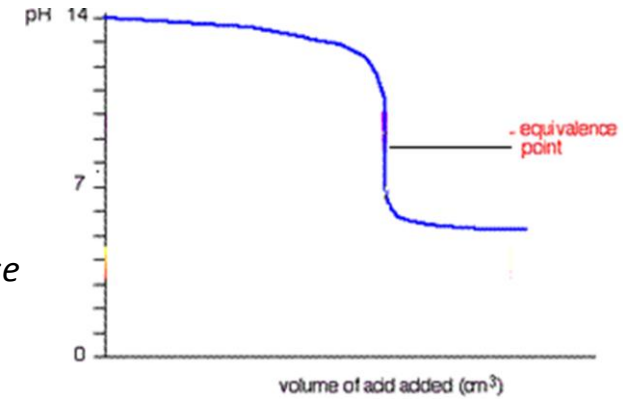
*Since this amount came from the 25.00mL sample of stock solution the concentration of the acetic acid in the stock solution is given by the expression*

⇨ *C = n/V = 0.0224/0.02500 = 0.896M*

g) Explain the difference between equivalence point and end point.

*End point is when the indicator changes colour while the equivalence point is when the reactants are added in the exact stoichiometric ratio as indicated by the equation. The end point follows the equivalence point by about one drop.*

h) A titration was conducted and the pH curve shown on the right. Select from the words below to complete the sentence.
*strong acid, weak acid, strong base, weak base*




A *strong base* is titrated against a *weak acid*

i) Two indicators are provided for students to use. Phenolphthalein and methyl orange. Which indicator should be used and why?
*Phenolphthalein because according to the data booklet provided it will change colour at a pH close to the equivalence point where as methyl orange will not change colour near the equivalence point.*

j) Explain why the equivalence point, shown on the pH curve above is not at pH of 7?
*When all the reactants have completely reacted $CH_3COONa$ and $H_2O$ remain. The $CH_3COO^-$ ion will react with the water to produce $OH^-$ ions.*

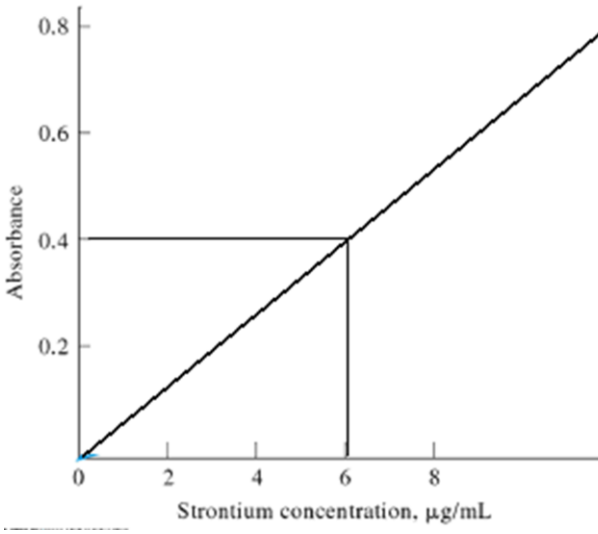
*$CH_3COO^-(aq) + H_2O(l) \Rightarrow CH_3COOH(aq) + OH^-(aq)$*
*This will give a pH greater than 7.*

2+2+2+2+2+3+2+2+ 2=19 marks

7) Strontium concentration of a polluted water-way was measured by atomic absorption. The calibration curve shown below was produced.

a) A 20.00 mL sample was analysed and found to have an absorbance of 0.4. Calculate the
i) mass of strontium in the 20.00 mL sample in grams.
*Concentration of strontium = 6 X $10^{-6}$ g/mL*
*=> in 20 mL the mass of strontium is*
*6 X $10^{-6}$ X 20 = 1.2 X $10^{-4}$ grams*
ii) The concentration of strontium in mol/L

*Convert the mass of strontium into mol*
*=> 1.2 X $10^{-4}$/87.6 =1.37 X $10^{-6}$*
*=> mol/L = 1.37 X $10^{-6}$/0.02 =6.85 X $10^{-5}$ M*




2+2=4 marks

b) What one other analytical technique could be used to analyse the concentration of strontium by first producing a calibration curve?
*UV-visible spectroscopy*

1 mark

c) What is the purpose of a calibration curve?
*To ascertain the relationship between absorbance and concentration for the particular equipment used.*

1 mark

d) Name two analytical techniques which require the use of a reference cell?
*UV-visible spectroscopy and IR spectroscopy*

2 marks

e) Why is a reference cell used?
*In IR a reference cell is used to discount the effects on the sample of the solvent and interference caused by water vapour and carbon dioxide as well as the ambient temperature of the room. In UV-visible it is used to compensate for any scattering, absorption or reflection of light by the solvent and the cell.*

2 marks

f) An ester used as a strawberry flavour in ice-creams can best be isolated and identified using which of the techniques below?
   a) IR spectroscopy and NMR spectroscopy
   b) Thin-layer chromatography and UV-visible spectroscopy
   c) Gas chromatography and NMR spectroscopy
   d) HPLC and UV-visible spectroscopy.

*C*

1 mark

g) Explain your answer to f) above.

*IR and NMR are used to provide information about the molecular structure of a molecule. UV-visible does not give any information of structure and absorbance over a certain band of the electromagnetic spectrum does not provide clear information to allow identification of the molecule. Thin-layer chromatography is not precise enough to separate esters. HPLC will adequately separate out the esters but it should not be coupled with UV-visible to identify the component esters. GC will certainly separate volatile compounds such as esters and NMR both $^{1}H$ and $^{13}C$ will provide information as to the structure of the molecule.*

2 marks

h) How can UV-visible spectroscopy be used to identify metal ions which are not coloured.
*The metal ions are converted to a coloured compound.*

1 mark

8) A 4.50 gram sample of baby food was analysed for sodium content. It is assumed all the sodium in the food originated from NaCl. The sample was dissolved in 100.00 mL of distilled water and filtered. The filtrate was diluted to 200.00mL by the addition of distilled water. A 20.0 mL sample of the diluted filtrate was reacted with excess silver nitrate solution and 0.150 grams of silver chloride was formed.

a) Calculate the amount of chloride ions present in mol in the baby food.

*$n_{AgCl}$ in the baby food = (0.150/143.4 ) X 10 = 0.0105 mol*

2 marks

b) Calculate the percentage by mass of sodium in the food.
*Mass of sodium present in the baby food = 0.0105 X 23.0 =0. 242g*
*% composition of Na = (0.242/4.50 ) X 100 = 5.38%*

2 marks