VCE CHEMISTRY 2007 TRIAL EXAM YEAR 12 UNIT 3

Time allowed: 90 minutes
Total marks: 84

SECTION A
Contains 20 multiple choice questions
22 minutes, 20 marks

SECTION B
7 Extended response questions
68 minutes, 64 marks

A data sheet and multiple choice answer sheet are provided. Answer extended response questions in the space provided. Use the marks and time allowed as a guide to how much time you should spend answering each question.

Periodic Table

		relative atomic number	1														2
		symbol	H														He
		name	Hydrogen														Helium
		relative atomic mass	1.0														4.0

3	4											5	6	7	8	9	10
Li	Be											B	C	N	O	F	Ne
Lithium	Beryllium											Boron	Carbon	Nitrogen	Oxygen	Fluorine	Neon
6.9	9.0											10.8	12.0	14.0	16.0	19.0	20.2
11	12											13	14	15	16	17	18
Na	Mg											Al	Si	P	S	Cl	Ar
Sodium	Magnesium											Aluminium	Silicon	Phosphorus	Sulfur	Chlorine	Argon
23.0	24.3											27.0	28.1	31.0	32.1	35.5	39.9
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Potassium	Calcium	Scandium	Titanium	Vanadium	Chromium	Manganese	Iron	Cobalt	Nickel	Copper	Zinc	Gallium	Germanium	Arsenic	Selenium	Bromine	Krypton
39.1	40.1	44.9	47.9	50.9	52.0	54.9	55.9	58.9	58.7	63.6	65.4	69.7	72.6	74.9	79.0	79.9	83.8
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Rubidium	Strontium	Yttrium	Zirconium	Niobium	Molybdenum	Technetium	Ruthenium	Rhodium	Palladium	Silver	Cadmium	Indium	Tin	Antimony	Tellurium	Iodine	Xenon
85.5	87.6	88.9	91.2	92.9	95.9	98.1	101.1	102.9	106.4	107.9	112.4	114.8	118.7	121.8	127.6	126.9	131.3
55	56	57	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Caesium	Barium	Lanthanum	Hafnium	Tantalum	Tungsten	Rhenium	Osmium	Iridium	Platinum	Gold	Mercury	Thallium	Lead	Bismuth	Polonium	Astatine	Radon
132.9	137.3	138.9	178.5	180.9	183.8	186.2	190.2	192.2	195.1	197.0	200.6	204.4	207.2	209.0	(209)	(210)	(222)
87	88	89	104	105	106	107	108	109	110	111	112		114				
Fr	Ra	Ac	Rf	Ha	Sg	Ns	Hs	Mt	Ds	Rg	Uub		Uuq				
Francium	Radium	Actinium	Rutherfordium	Hahnium	Seaborgium	Neilsbohrium	Hassium	Meitnerium	Darmstadtium	Roentgenium	Ununbium		Ununquadium				
(223)	(226)	(227)	(261)	(262)	(266)	(264)	(269)	(268)	(272)	(272)	(277)		(289)				

Lanthanide series

58	59	60	61	62	63	64	65	66	67	68	69	70	71
Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Cerium	Praseodymium	Neodymium	Promethium	Samarium	Europium	Gadolinium	Terbium	Dysprosium	Holmium	Erbium	Thulium	Ytterbium	Lutetium
140.1	140.9	144.2	(145)	150.3	152.0	157.2	158.9	162.5	164.9	167.3	168.9	173.0	175.0

Actinide series

90	91	92	93	94	95	96	97	98	99	100	101	102	103
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr
Thorium	Protactinium	Uranium	Neptunium	Plutonium	Americium	Curium	Berkelium	Californium	Einsteinium	Fermium	Mendelevium	Nobelium	Lawrencium
232.0	231.0	238.0	237.1	(244)	(243)	(247)	(247)	(251)	(254)	(257)	(258)	(255)	(256)

DATA SHEET

Physical Constants

F	$= 96\ 500\ \text{C mol}^{-1}$	**Ideal gas equation**
R	$= 8.31\ \text{JK}^{-1}\text{mol}^{-1}$	$pV = nRT$
V_m (STP)	$= 22.4\ \text{L mol}^{-1}$	
V_m (SLC)	$= 24.5\ \text{L mol}^{-1}$	

Specific heat of water $= 4.184\ \text{J mL}^{-1}\ {}^{\circ}\text{C}^{-1}$

The Electrochemical Series

E° in volt

		E°
$F_2(g) + 2e^-$	$\rightarrow 2F^-(aq)$	+ 2.87
$H_2O_2(aq) + 2H^+(aq) + 2e^-$	$\rightarrow 2H_2O(l)$	+ 1.77
$Au^+(aq) + e^-$	$\rightarrow Au(s)$	+ 1.68
$MnO_4^-(aq) + 8H^+(aq) + 5e^-$	$\rightarrow Mn^{2+}(aq) + 4H_2O(l)$	+ 1.50
$Cl_2(g) + 2e^-$	$\rightarrow 2Cl^-(aq)$	+ 1.36
$O_2(g) + 4H^+(aq) + 4e^-$	$\rightarrow 2H_2O(l)$	+ 1.23
$Br_2(l) + 2e^-$	$\rightarrow 2Br^-(aq)$	+ 1.09
$Ag^+(aq) + e^-$	$\rightarrow Ag(s)$	+ 0.80
$Fe^{3+}(aq) + e^-$	$\rightarrow Fe^{2+}(aq)$	+ 0.77
$I_2(s) + 2e^-$	$\rightarrow 2I^-(aq)$	+ 0.54
$O_2(g) + 2H_2O(l) + 4e^-$	$\rightarrow 4OH^-(aq)$	+ 0.40
$Cu^{2+}(aq) + 2e^-$	$\rightarrow Cu(s)$	+ 0.34
$CO_2(g) + 8H^+(aq) + 8e^-$	$\rightarrow CH_4(g) + 2H_2O(l)$	+ 0.17
$S(s) + 2H^+(aq) + 2e^-$	$\rightarrow H_2S(g)$	+ 0.14
$2H^+(aq) + 2e^-$	$\rightarrow H_2(g)$	0.00
$Pb^{2+}(aq) + 2e^-$	$\rightarrow Pb(s)$	- 0.13
$Sn^{2+}(aq) + 2e^-$	$\rightarrow Sn(s)$	- 0.14
$Ni^{2+}(aq) + 2e^-$	$\rightarrow Ni(s)$	- 0.23
$Co^{2+}(aq) + 2e^-$	$\rightarrow Co(s)$	- 0.28
$Fe^{2+}(aq) + 2e^-$	$\rightarrow Fe(s)$	- 0.44
$Zn^{2+}(aq) + 2e^-$	$\rightarrow Zn(s)$	- 0.76
$2H_2O(l) + 2e^-$	$\rightarrow H_2(g) + 2OH^-(aq)$	- 0.83
$Mn^{2+}(aq) + 2e^-$	$\rightarrow Mn(s)$	- 1.03
$Al^{3+}(aq) + 3e^-$	$\rightarrow Al(s)$	- 1.67
$Mg^{2+}(aq) + 2e^-$	$\rightarrow Mg(s)$	- 2.34
$Na^+(aq) + e^-$	$\rightarrow Na(s)$	- 2.71
$Ca^{2+}(aq) + 2e^-$	$\rightarrow Ca(s)$	- 2.87
$K^+(aq) + e^-$	$\rightarrow K(s)$	- 2.93
$Li^+(aq) + e$	$\rightarrow Li(s)$	- 3.02

Student Name..

VCE Chemistry 2007 Year 12 Trial Exam Unit 3

SECTION A
MULTIPLE CHOICE ANSWER SHEET

Instructions:
For each question choose the response that is correct or best answers the question.
Circle the chosen response on this answer sheet.
Only circle **one** response for each question.

Question 1.	A	B	C	D
Question 2.	A	B	C	D
Question 3.	A	B	C	D
Question 4.	A	B	C	D
Question 5.	A	B	C	D
Question 6.	A	B	C	D
Question 7.	A	B	C	D
Question 8.	A	B	C	D
Question 9.	A	B	C	D
Question 10.	A	B	C	D
Question 11.	A	B	C	D
Question 12.	A	B	C	D
Question 13.	A	B	C	D
Question 14.	A	B	C	D
Question 15.	A	B	C	D
Question 16.	A	B	C	D
Question 17.	A	B	C	D
Question 18.	A	B	C	D
Question 19.	A	B	C	D
Question 20.	A	B	C	D

VCE Chemistry 2007 Year 12 Trial Exam Unit 3

Section A
Section A consists of 20 multiple-choice questions.
Section A is worth approximately 24 per cent of the marks available.
*Choose the response that is **correct** or **best answers** the question.*
Indicate your choice on the answer sheet provide.

Question 1.
A sample of anhydrous sodium carbonate, Na_2CO_3, is dissolved in enough water to make exactly three litres of solution. The concentration of this solution with respect to sodium ions, Na^+, was 0.0430 mol L^{-1}. The mass of Na_2CO_3 used to make this solution was
A.   3.42 g
B.   5.35 g
C.   6.84 g
D.   13.7 g

Question 2.
Two 25.0 mL samples of an aqueous solution of sodium hydroxide were neutralised separately by strong acids. One sample required 22.5 mL of 0.100 M hydrochloric acid and the other sample required 7.50 mL of sulfuric acid solution.
The concentration of the sulfuric acid was
A.   0.200 mol L^{-1}
B.   0.150 mol L^{-1}
C.   0.100 mol L^{-1}
D.   0.0500 mol L^{-1}

Question 3.
Ammonia is a weak base, which ionises in water according to the equation
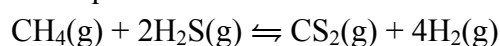$$NH_3(aq) + H_2O(l) \rightleftharpoons NH_4^+(aq) + OH^-(aq).$$
If 20 mL of 0.10 M NH_3(aq) is added to 50 mL of water, which of the following correctly describes the expected change in pH and number of ammonia molecules, i.e. $N(NH_3)$, present due to the dilution.
A.   pH increases, $N(NH_3)$ increases
B.   pH decreases, $N(NH_3)$ increases
C.   pH increases, $N(NH_3)$ decreases
D.   pH decreases, $N(NH_3)$ decreases
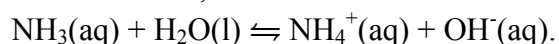
Question 4.
The equilibrium constant for the reaction
$$CH_4(g) + 2H_2S(g) \rightleftharpoons CS_2(g) + 4H_2(g)$$
at 900°C is 3.59.
In an analysis of a reaction mixture at 900°C, the concentration data collected was
$[CH_4] = 0.575$ M, $[H_2S] = 0.600$ M, $[CS_2] = 0.755$ M, $[H_2] = 1.08$ M
According to this data
A.   the reaction is at equilibrium
B.   the reaction must continue to the right for equilibrium to be established
C.   the reaction must continue to the left for equilibrium to be established
D.   the reaction is endothermic

Question 5.

Methanoic acid and propanoic acids are both weak monoprotic acids.

The acidity constants for these acids, at 25°C, are

HCOOH – 1.8×10^{-4}; CH_3CH_2COOH – 1.3×10^{-5}

Which of the following statements relating to aqueous solutions of these acids at 25°C is most likely to be correct?

A.   methanoic acid has a higher concentration of H_3O^+ and a lower pH
B.   methanoic acid has a higher concentration of H_3O^+ and a higher pH
C.   methanoic acid has a lower concentration of H_3O^+ and a lower pH
D.   methanoic acid has a lower concentration of H_3O^+ and a higher pH

Question 6.

At 60°C, the pH of pure water is 6.5 The number of $H^+(aq)$ ions present in 1.0 mL of pure water at 60°C is

A. 3.16×10^{-7}
B. 3.16×10^{-10}
C. 1.90×10^{14}
D. 1.90×10^{15}

Question 7.

The reaction between excess calcium carbonate and hydrochloric acid occurs according to the equation $CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$.

This reaction is exothermic

In an investigation of the rate of this reaction, the following graph was plotted from data collected.

Time
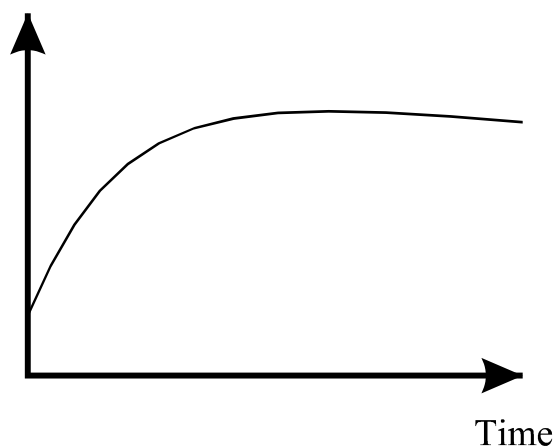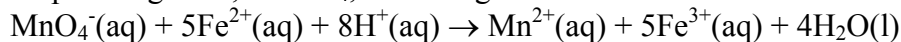
A suitable quantity for the vertical axis of the graph would be

A.   temperature
B.   number of calcium ions
C.   concentration of HCl(aq)
D.   number of $H^+(aq)$ ions

Question 8.
In an experiment to determine the percentage of iron in a nail, a sample of the nail was weighed and then allowed to react completely with sulfuric acid to convert all of the Fe(s) present to Fe^{2+}(aq) according to the equation $Fe(s) + 2H^+(aq) \rightarrow Fe^{2+}(aq) + H_2(g)$
The amount of Fe^{2+}(aq) present in the solution was then determined via titration with acidified potassium permanganate, $KMnO_4$, according to the reaction
$$MnO_4^-(aq) + 5Fe^{2+}(aq) + 8H^+(aq) \rightarrow Mn^{2+}(aq) + 5Fe^{3+}(aq) + 4H_2O(l)$$
On the basis of the data collected, the iron content of the nail was calculated to be 104%.
Which of the following explanations is **unlikely** to be the cause of this error?
A. $KMnO_4$(aq) was added past the endpoint of the titration.
B.   The $KMnO_4$(aq) was less concentrated than the concentration stated on the bottle and used in the calculations.
C.   The mass of the nail sample was incorrectly recorded as 1.245 g rather than the correct 1.425 g
D.   Some of the iron in the solution was converted to Fe^{3+}(aq) by atmospheric oxygen prior to the titration.

Question 9.
In 1894, when Lord Rayleigh and William Ramsay removed oxygen, nitrogen, carbon dioxide and water from a sample of air, a small quantity of gas remained. This gas was shown to be a pure sample of a monatomic element which produced a unique emission spectrum, indicating that they had discovered an new element.
500 mL of this gas had a mass of 0.815 g at 25°C and 101.3 kPa pressure. The element discovered by Rayleigh and Ramsay was
A.   helium
B.   neon
C.   argon
D.   krypton

Question 10.
Molecules of a particular ester contain 7 carbon atoms. The percentage by mass of oxygen in each molecule of this ester would be closest to
A.   32
B.   25
C.   13
D.   9

Question 11.
Polymers formed from monomers with the general formula $H_2C=CHX$
A.   are produced by substitution reactions.
B.   contain C=C bonds.
C.   are more reactive than the monomer.
D.   have the same percentage, by mass, of carbon as the monomer.

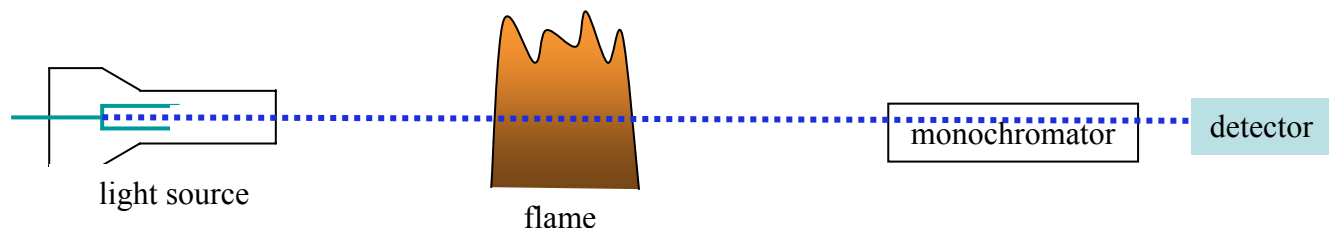**Question 12.**
The semistructural formula of an organic compound is $CH_3(CH_2)_8COOH$.
Which of the following statements concerning this substance is **incorrect**?
A.   The compound may be produced by the oxidation of an alkane by acidified dichromate.
B.   There are four non-bonding electron pairs in a molecule of the compound.
C.   Molecules of the substance are polar.
D.   The empirical formula of the compound is $C_5H_{10}O$.

Question 13.

The development of the atomic absorption spectrophotometer, one of the most significant in Australian chemical technology, was an initiative of Alan Walsh and his team at the CSIRO in the 1950's. The key components of the instrument are represented in the diagram below.
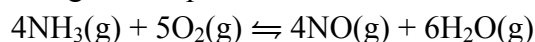

light source

flame

monochromator

detector

Which component is changed for the analyses of different metals?
A.   the light source
B.   the flame
C.   the monochromator
D.   the detector

Question 14.

The first stage in the production of nitric acid from ammonia involves the equilibrium

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$$

The NO produced is then converted to NO_2 which in turn is converted to nitric acid. HNO_3.
A catalyst is used in the production of NO from NH_3. The best description of the effect of the catalyst is that it
A.   increases the amount of NO produced from a specific amount of NH_3
B.   increases the rate of oxidation of NH_3
C.   increases both the rate of oxidation of NH_3 and the rate of reduction of NO
D.   ensures that NH_3 is not converted directly to NO_2 at high temperatures.

Question 15.

The energy profile below is for the general reaction $\mathbf{P + Q \rightleftharpoons R + S}$
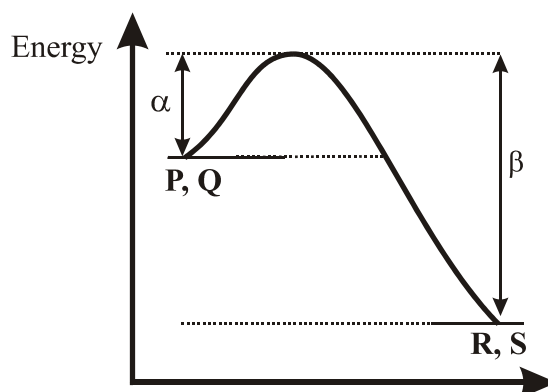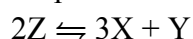

According to this energy profile
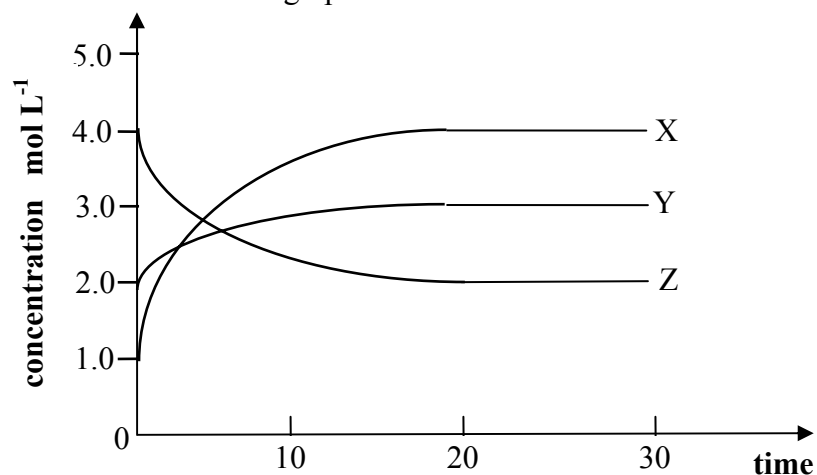A.   the reactants are more stable and the ΔH is equal to $\alpha - \beta$
B.   the products are more stable and the ΔH is equal to $\alpha - \beta$
C.   the reactants are more stable and the ΔH is equal to $\beta - \alpha$
D.   the products are more stable and the ΔH is equal to $\beta - \alpha$

Question 16.
When compound Z decomposes, it does so according to the equilibrium

$$2Z \rightleftharpoons 3X + Y$$

A concentration-time graph for the reaction is shown below.

According to this data, the value of the equilibrium constant is
A.   0.021
B.   0.13
C.   6.0
D.   48

Question 17.
Butanoic acid is a weak acid with $K_a = 1.30 \times 10^{-5}$ at 25°C.
The pH of a 0.00100 M solution of butanoic acid, at 25°C would be closest to
A.   0.943
B.   3.00
C.   3.94
D.   7.89

Question 18.

The concentration of copper ions in a solution was determined by converting the $Cu^{2+}(aq)$ ions to $Cu(NH_3)_4^{2+}(aq)$ ions and measuring the absorbance of the solution in a UV-Visible spectrometer. A series of $Cu(NH_3)_4^{2+}(aq)$ standards were prepared and used to obtain the calibration curve below.
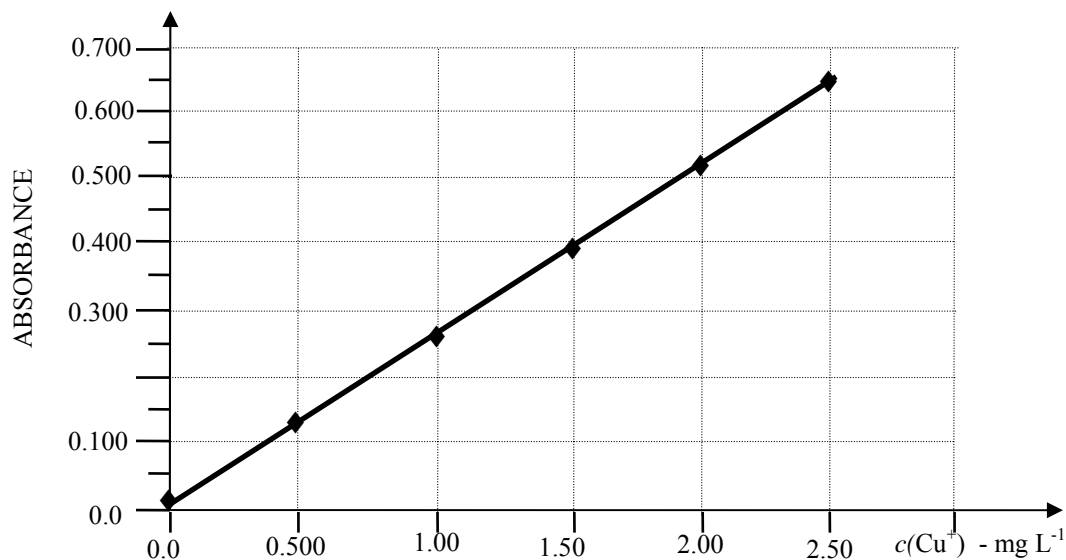
A 10.0 mL sample of the original solution was diluted to 100 mL with deionised water. Then 5.00 mL of this diluted solution was further diluted to 100 mL with deionised water prior to analysis

The absorbance of the final dilute solution was 0.520

The concentration of the original solution with respect to $Cu^{2+}(aq)$ ions was

A.   2.00 mg L^{-1}
B.   20.0 mg L^{-1}
C.   200 mg L^{-1}
D.   400 mg L^{-1}

Question 19.

When 50 mL of a 0.020 M solution of $Ba(OH)_2$ is added to 50 mL of a 0.060 M solution of HNO_3 and reaction allowed to proceed to completion at 25°C , the pH of solution remaining after reaction will be

A.   1.7
B.   2.0
C.   7.0
D.   13

Question 20.

Consider the list of chemical formulae given below

$HOCH_2CH_2OH$, HNO_3, H_2O, HCO_3^-, $C_2H_4Cl_2$, SO_2, V_2O_5, H_2SO_3, C_5H_{12}

Which of the following is **not** present in this list?

A.   an amphiprotic species
B.   an unsaturated hydrocarbon
C.   a reactant that could be used in the production of a polyester
D.   an industrial catalyst

Section B.

Section B consists of 7 short answer questions. You should answer all of these questions.
This section is worth approximately 76 per cent of the total marks available.
The marks allotted are shown at the end of each part of each question.
Questions should be answered in the spaces provided.

Question 1

A 1.32 g sample of a monoprotic acid is dissolved in water to produce 200 mL of solution.
25.0 mL aliquots of this solution are then titrated with 0.1000 M sodium hydroxide solution and
the average titre required to reach the endpoint is 27.48 mL

(a)   Determine the concentration of the acid solution.

2 marks

(b)   Determine the molar mass of the acid.

2 marks

(c)   If the acid has the empirical formula CH_2O, determine its molecular formula and give its
systematic name.

2 marks

(d)   This acid can be produced in three steps from a saturated hydrocarbon. Using
semistructural formulae show the steps in this preparation and give the formulae of other
reactants needed for each step.

4 marks

(e)   Acids are involved in ester production. Using semistructural formula write a balanced equation for the production of 2-propyl propanoate. Also, explain why such reactions usually involve the use of two different acids.

3 marks
Total 13 marks

Question 2.
The flowchart below represents the stages in the production of sulfuric acid using the contact process.

S

Stage 1

SO_2

Stage 2

SO_3

Stage 3

H_2SO_4
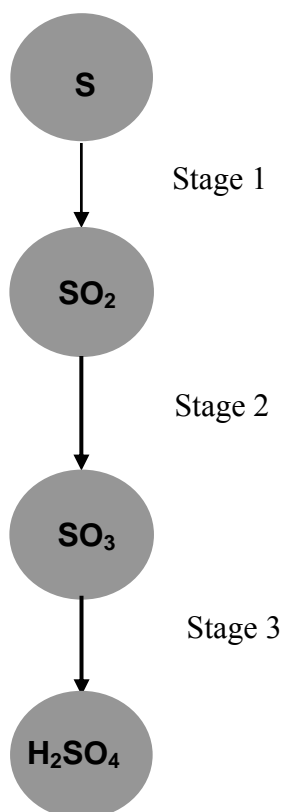
(a)   Stage 1
        (i)   Where does this reaction occur?

1 mark
        (ii)   What oxidation number changes occur in this stage?

1 mark

       (iii)   What type of reaction occurs?

1 mark

(b)   Stage 2.
       (i)   Where does this reaction occur?

1 mark

       (ii)   Write a balanced equation for the reaction.

1 mark

       (iii)   State whether this reaction is exothermic or endothermic and explain how this influences the reaction conditions used?

3 marks

       (iv)   Explain why the pressures used for this reaction are not consistent with Le Chatelier's principle.

2 marks

(c)   Stage 3.
       (i)   Where do the reactions associated with this stage occur?

1 mark

       (ii)   Write balanced equations for the reactions associated with this stage.

2 marks

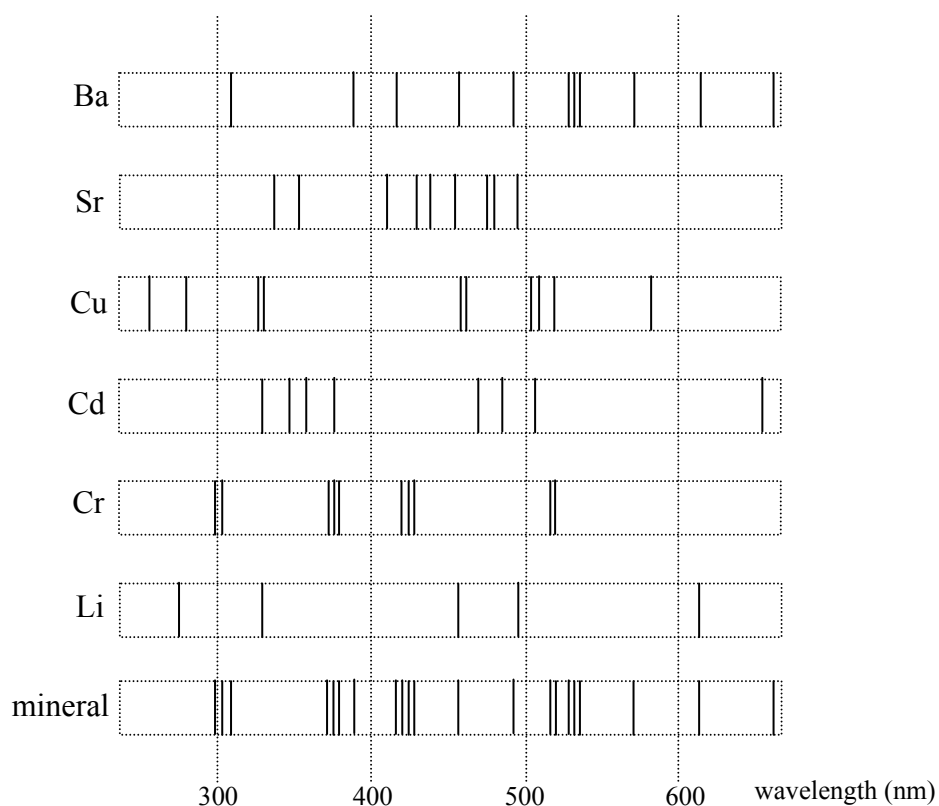(iii)   Explain why SO_3 is not directly converted to H_2SO_4 via reaction with water.

1 mark

(iv)   What oxidation number change occurs in this stage?

1 mark
Total 15 marks

Question 3
The emission spectrum of a sample of a mineral is shown below along with the emission spectra of a number of elements.

(a)   Explain how an emission spectrum is produced and why each element has a unique spectrum.

3 marks

(b)   According to the emission spectra shown which elements are present in the mineral
        sample.

2 marks

(c)   What analytical technique would most likely be used to determine the relative amounts of
        each element in the mineral?

1 mark
Total 6 marks

Question 4.
A 5.623 g sample of NaOH(s) is weighed in an open container and then transferred to a 250 mL
volumetric flask. Deionised water is added up to the calibration mark and the flask and contents
are thoroughly shaken to ensure that all of the NaOH dissolves.
(a)   Calculate the concentration of the sodium hydroxide solution produced.

1 mark

(b)   Sodium hydroxide is not used as a primary standard because the concentrations of NaOH
        solutions produced in this way are usually slightly lower than calculated from the mass of
        NaOH used. Give a reason why the actual concentration is most likely lower than the
        calculated concentration.

1 mark

(c)   What chemical property would be required of a primary standard used to determine the
        accurate concentration of an NaOH(aq) solution.

1 mark

(d)   Oxalic acid, $H_2C_2O_4.2H_2O$ is a primary standard used to determine the concentration of
        sodium hydroxide solutions.
        2.054 g of $H_2C_2O_4.2H_2O$ was dissolved in water and the solution made up to 100 mL in a
        volumetric flask. A 25.00 mL aliquot of the oxalic acid solution was titrated with a
        NaOH(aq) solution. 18.41 mL of the NaOH(aq) was needed to reach the endpoint.

(i) Oxalic acid is a diprotic acid. Write a balanced equation for its reaction with sodium hydroxide.
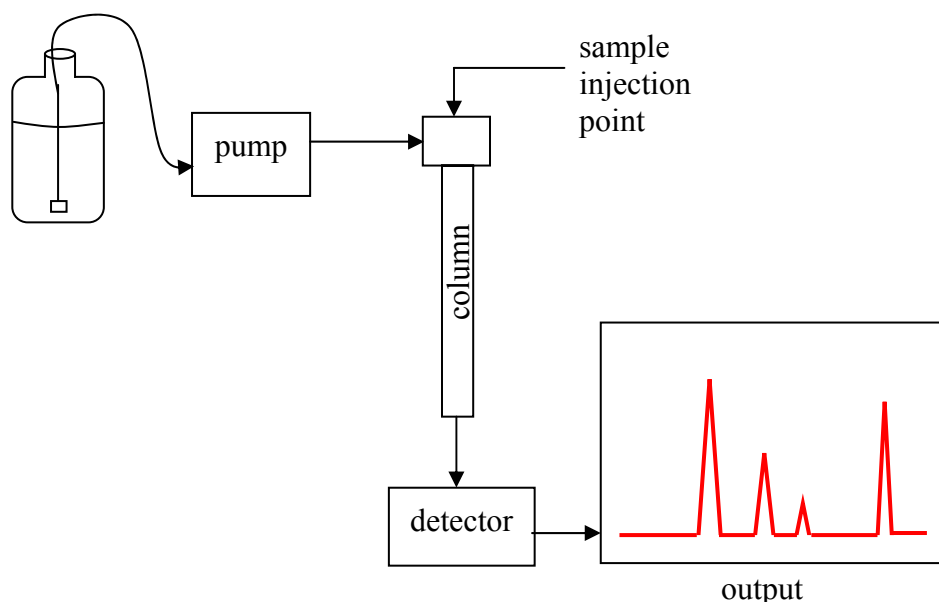
1 mark

(ii) Determine the concentration of the sodium hydroxide solution.

4marks
Total 8 marks

Question 5.
The diagram below shows the key components of a type of chromatography.

(a) What type of chromatography is represented in this diagram?

1 mark

(b) Give the name of the other type of chromatography which also involves a column?

1 mark

(c)   Describe the differences between the mobile and stationary phases in the types of chromatography identified in (a) and (b) and explain the functions of the mobile and stationary phases common to all types of chromatography.

4 marks

(d)   (i)   Identify the measurement used to identify the components of a mixture separated by column chromatography and explain what a high value implies.

1 mark

(ii)   Identify the measurement used to identify the components of a mixture separated by paper chromatography and explain how its value is determined.

2 marks

(iii)   Justify the claim that 'a high value of the measurement in (i) is consistent with a low value of the measurement in (ii)'.
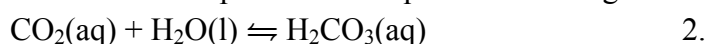
1 mark
Total 10 marks

Question 6.
One component of blood pH control utilises the $H_2CO_3(aq)/HCO_3^-(aq)$ buffer system and the rate at which CO_2 is removed from the lungs.
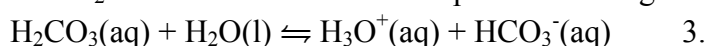This mechanism in effect, involves three equilibria:-

$$CO_2(g) \rightleftharpoons CO_2(aq) \qquad\qquad 1.$$

CO_2 dissolved in blood plasma is in equilibrium with gaseous CO_2 in the lungs

$$CO_2(aq) + H_2O(l) \rightleftharpoons H_2CO_3(aq) \qquad\qquad 2.$$

Dissolved CO_2 reacts with water in blood plasma forming carbonic acid, $H_2CO_3(aq)$

$$H_2CO_3(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + HCO_3^-(aq) \qquad 3.$$

The equilibrium between carbonic acid, a weak acid, and its conjugate base hence forming a buffer solution.

(a)   A buffer solution can resist significant changes in pH on addition of small amounts of a strong acid or a strong base. Describe how the equilibrium between carbonic acid and its conjugate base would respond to changes in pH.

2 marks

(b)   Some of the receptors in the brain are sensitive to the concentrations of H^+ and CO_2 in the blood. Referring to the supplied equilibria, explain why a decrease in blood pH causes these receptors to trigger a reflex to breathe faster and deeper?

2 marks

(c)   Oxygen enters the blood through the lungs when it binds with haemoglobin (Hb) found in red blood cells. Haemoglobin also binds H^+, so the equilibrium

$$HbH^+ + O_2 \rightleftharpoons HbO_2 + H^+$$
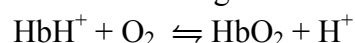
exists in the blood.
According to this equilibrium what happens to the pH of oxygenated blood when it reaches tissue where the concentration of O_2 is low?

1 mark

(d)   How does breathing in carbon monoxide interfere with oxygen transport around the body?

1 mark
Total 6 marks

Question 7.
Many organic chemicals used as feedstocks in the petrochemical industry are obtained by the fractional distillation of crude oil. The fractions obtained are made up of alkanes of similar boiling temperatures. These often are cracked to produce 'lighter', more useful hydrocarbons.

(a)   Which of the two alkanes, heptane and hexane, has the higher boiling temperature? Explain

1 mark

(b)   Controlled cracking of decane may produce equal mole amounts of 1-butene, 2-butene and one other hydrocarbon. Using semi-structural formulae write a balanced equation describing this process.

2 marks

(c)   Justify the claim that high temperatures favour both the rate and yield in cracking reactions.

1 mark

(d)   State common uses of the two different **types** of hydrocarbons produced by cracking.

2 marks
Total 6 marks

Suggested Solutions VCE Chemistry 2007 Year 12 Trial Exam Unit 3

Section A

Q1. **C** In aqueous solution Na_2CO_3 dissociates according to

$Na_2CO_3(s) + aq \rightarrow 2Na^+(aq) + CO_3^{2-}(aq)$

$n(Na^+)$ in solution $= c(Na^+)$ x V(solution)

$= 0.0430$ mol L^{-1} x 3.00 L

$= 0.129$ mol

So $n(Na_2CO_3)$ dissolved $= \frac{1}{2}$ x $n(Na^+)$

$= \frac{1}{2}$ x 0.129

$= 0.0645$ mol

$n(Na_2CO_3) = n(Na_2CO_3)$ x $M(Na_2CO_3)$

$= 0.0645$ mol x 106 g mol^{-1}

$= $ **6.84 g** …….*3 significant figures*

Q2. **B** Neutralisation equations:

$NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$

$n(HCl)$ required $= n(NaOH)$

$2NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + H_2O(l)$

$n(H_2SO_4)$ required $= \frac{1}{2}$ x $n(NaOH)$

Since the $n(NaOH)$ reacting is the same in both cases, then

$n(H_2SO_4)$ required $= \frac{1}{2}$ x $n(HCl)$ required

$n(HCl)$ required $= c(HCl)$ x $V(HCl)$

$= 0.100$ x 22.5×10^{-3}

$= 2.25\times10^{-2}$ mol

$n(H_2SO_4)$ required $= \frac{1}{2}$ x 2.25×10^{-2}

$= 1.125\times10^{-2}$ mol

$c(H_2SO_4) = n(H_2SO_4)$ / $V(H_2SO_4)$

$= 1.125\times10^{-2}$ mol L^{-1} / 7.50×10^{-3} L

$= $ **0.150 M**

Q3. **D.** The addition of 20 mL of 0.10 M $NH_3(aq)$ to 50 mL of water pushes the equilibrium

$NH_3(aq) + H_2O(l) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$ to the right

This is consistent with Le Chatelier's principle – the system moves to compensate for the extra reactant, H_2O, by favouring the forward reaction until equilibrium is again reached.

So the **number of NH_3 molecules decreases** and the number of OH^- ions (the pH key) increases.

However since the total volume has increased, the increase in $n(OH^-)$ will not be enough to compensate for the volume increase. The $[OH^-]$ will be lower at the new equilibrium and consequently the **pH** will be **lower.**

Q4. **C** $CH_4(g) + 2H_2S(g) \rightleftharpoons CS_2(g) + 4H_2(g)$; $K = 3.59$

Comparison of the concentration fraction (*CF*) based on the supplied data with the value of the equilibrium constant provides insight into the 'position' of the reaction.

$CF = [CS_2][H_2]^4$ / $[CH_4][H_2S]^2$

$= (0.755$ x $1.08^4)$ / $(0.575$ x $0.600^2)$

$= 1.027$ / 0.207

$= 4.96$

Since the *CF* (4.96) is not equal to *K* (3.59), the reaction is not at equilibrium.

For equilibrium to be established the value of the concentration fraction must decrease. This requires a decrease in the product concentrations relative to the reactant concentrations, so the **reaction must continue to the left** for equilibrium to be established.

Q5. **A** The acids ionise in aqueous solution according to

$HCOOH(aq) + H_2O(l) \rightleftharpoons HCOO^-(aq) + H_3O^+(aq);\ K_a = 1.8 \times 10^{-4}$

$CH_3CH_2COOH + H_2O(l) \rightleftharpoons CH_3CH_2COO^-(aq) + H_3O^+(aq);\ K_a = 1.3 \times 10^{-5}$

Since **HCOOH**(aq) has the higher acidity constant, it will ionise slightly more than CH_3CH_2OH(aq), thus producing a **higher** $c(H_3O^+)$ and a **lower pH**.

Q6. **C** In pure water at 60°C, the $[H^+] = 10^{-6.5}$
$$= 3.16 \times 10^{-7}\ M$$
So $n(H^+)$ present $= c(H^+) \times V$
$$= 3.16 \times 10^{-7} \times 1.0 \times 10^{-3}$$
$$= 3.16 \times 0^{-10}\ mol$$
$N(H^+) = n(H^+) \times N_A$
$$= 3.16 \times 10^{-10} \times 6.02 \times 10^{23}$$
$$= \mathbf{1.90 \times 10^{14}\ ions}$$

Q7. **A** As the reaction $CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$ proceeds, it slows down so the rate of change of any measurable quantity slows down as indicated by the decreasing gradient of the graph. However the graph shows that the measured quantity was one that increased with time, albeit more slowly. Consider the alternatives.
A. Since the reaction is exothermic, the **temperature** of the solution surrounding the reacting particles **increases** as energy is released during the reaction. Hence, a temperature time graph would look like the graph shown in the question. Note: If one reactant was consumed the graph would flatten and start to trend down.
B. The number of calcium ions present does not change during the reaction. Ca^{2+} ions present in $CaCO_3(s)$ are released into aqueous solution in $CaCl_2(aq)$
C. Since HCl (aq) is a reactant, the c(HCl) will decrease with time.
D. The equation $CaCO_3(s) + 2H^+(aq) \rightarrow Ca^{2+}(aq) + H_2O(l) + CO_2(g)$ indicates that H^+(aq) is a reactant and so its concentration will decrease with time.

Q8. **D** According to the equations
$Fe(s) + 2H^+(aq) \rightarrow Fe^{2+}(aq) + H_2(g)$ and
$MnO_4^-(aq) + 5Fe^{2+}(aq) + 8H^+(aq) \rightarrow Mn^{2+}(aq) + 5Fe^{3+}(aq) + 4H_2O(l)$
n(Fe) in the iron nail sample $= n(Fe^{2+})$ reacting with MnO_4^-
$$= 5\ x\ n(MnO_4^-)$$
Consider the alternatives:
A. If the $KMnO_4$ was added past the endpoint, i.e. a larger volume of MnO_4^- was recorded than was needed to react with the Fe^{2+}, then $n(MnO_4^-)$ used would be calculated as higher than it should be leading to a higher calculated n(Fe) and ultimately a **higher than true calculated % Fe**.
B. If the $KMnO_4$ concentration was lower than stated, the volume of MnO_4^- used would be larger (than it would be for the recorded concentration) hence also leading to a **higher than true calculated % Fe**.

C. If the mass of the nail used in the calculations was smaller than it should be this would also lead to a **higher than true calculated % Fe**.
e.g. assuming the mass of Fe in the nail was 1.30 g
for 1.425 g nail sample; % Fe $= (1.30 / 1.425)$ x 100
$= 91.3$ %
for 1.245 g nail sample; % Fe $= (1.30 / 1.245)$ x 100
$= 104$ %

D. If some of the Fe^{2+}(aq) was converted to Fe^{3+}(aq), according to
$4Fe^{2+}$(aq) $+ O_2$(g) $+ 4H^+$(aq) $\rightarrow 4Fe^{3+}$(aq) $+ 2H_2O$(l)
prior to the titration then a smaller volume of MnO_4^-(aq) would be required to reach the endpoint. Consequently, the $n(MnO_4^-)$ used would be calculated as lower than it should be leading to a lower calculated $n(Fe)$ and ultimately a **lower than true calculated % Fe**.

Q9.   C   From the general gas equation $pV = nRT$
n(gas) $= pV / RT$
$= [101.3$ x $500\text{x}10^{-3}] / [8.31$ x $(25+273)]$
$= 0.0205$ mol
Since this gas sample weighed 1.63 g, the molar mass of the element can be determined
$n = m / M \rightarrow nM = m \rightarrow M = m / n$
$= 0.815 / 0.0205$
$= 39.8$ g mol^{-1}
The relative atomic mass of the element is close to 39.8, i.e. **Argon, Ar.**

Q10.   B   Esters are isomeric with carboxylic acids which have the same number of C atoms and so have the same molecular formula, i.e. $C_nH_{2n}O_2$.
Heptanoic acid, $CH_3CH_2CH_2CH_2CH_2CH_2COOH$, has the molecular formula, $C_7H_{14}O_2$.
Consider two possible esters with 7 carbon atoms:-
$CH_3CH_2CH_2COOCH_2CH_2CH_3$, i.e. 1-propyl butanoate
$CH_3CH_2CH_2CH_2COOCH_2CH_3$, i.e. ethyl pentanoate.
Both of these esters have the molecular formula $C_7H_{14}O_2$.
To work out the %, by mass, of O in the ester, assume a 1 mol sample.
$M(C_7H_{14}O_2) = 130$ g mol^{-1}
130 g $C_7H_{14}O_2$ molecules contains 2 mol O atoms, i.e. 32 g O atoms.
% O $= [m(O) / m(C_7H_{14}O_2)]$ x 100
$= [32 / 130]$ x 100
$= $ **24.6 %**

Q11.   D   Polymers formed from alkenes or alkene derivatives such as vinyl chloride, $H_2C{=}CHCl$, or styrene, $H_2C{=}CH(C_6H_5)$, are addition polymers formed by addition reactions in which the C=C double bonds are converted into single bonds, e.g. styrene $\rightarrow$ polystyrene

The other distinguishing feature about addition polymerisation is that there is no change in the identity or number of atoms present, so the %, by mass, of carbon in the polymer is the same as it is in the monomer from which the polymer was produced.

Q12. **A.** $CH_3(CH_2)_8COOH$ is a decanoic acid. Its structure
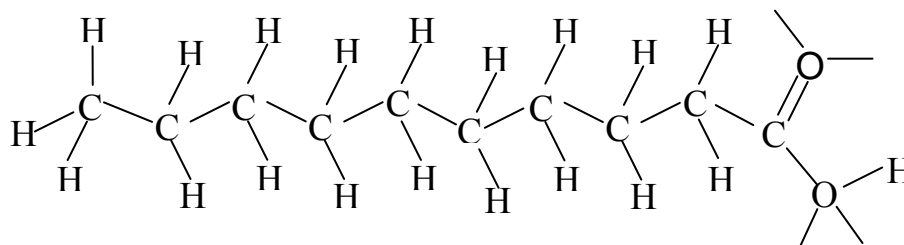
indicates that it has four non-bonding pairs of electrons in each molecule and is polar because of the dipolar O-H bonds.

$CH_3(CH_2)_8COOH$ indicates that the molecular formula is $C_{10}H_{20}O_2$, from which it can be deduced that the empirical formula is $C_5H_{10}O$.

However whilst $CH_3(CH_2)_8COOH$ can be prepared from decane, $CH_3(CH_2)_8CH_3$, it cannot be done directly. Rather the reaction sequence would be

$CH_3(CH_2)_8CH_3 \rightarrow CH_3(CH_2)_8CH_2Cl \rightarrow CH_3(CH_2)_8CH_2OH \rightarrow CH_3(CH_2)_8COOH$.

Acidified dichromate is only used in the last stage the conversion of 1-decanol to decanoic acid.

Q13. **A.** Atomic absorption spectroscopy depends on electrons in the metal atoms being excited to higher energy levels. This requires wavelengths of light consistent with the energy difference between the energy levels. Because atoms of different elements have unique electron arrangements, they require different wavelengths of light to excite electrons to higher energy levels and so the **lamp used as the light source must produce light of wavelengths specific to the element** for which the analysis is being performed. This is achieved by the cathode of the lamp being made of the same metal.

So if analysing for nickel an Ni lamp is used, if analysing for gold an Au lamp is used and so on.

Q14. **C** In the reaction described by the equation

$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$
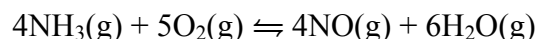
NH_3 is oxidised to NO in the forward reaction – the oxidation number of N increases from -3 to +2. Consequently in the reverse reaction, NO is reduced to NH_3.

Since a catalyst increases the rates of both the forward and reverse reactions, in this equilibrium reaction using a catalyst will increase both the rate of oxidation of NH_3 and the rate of reduction of NO.
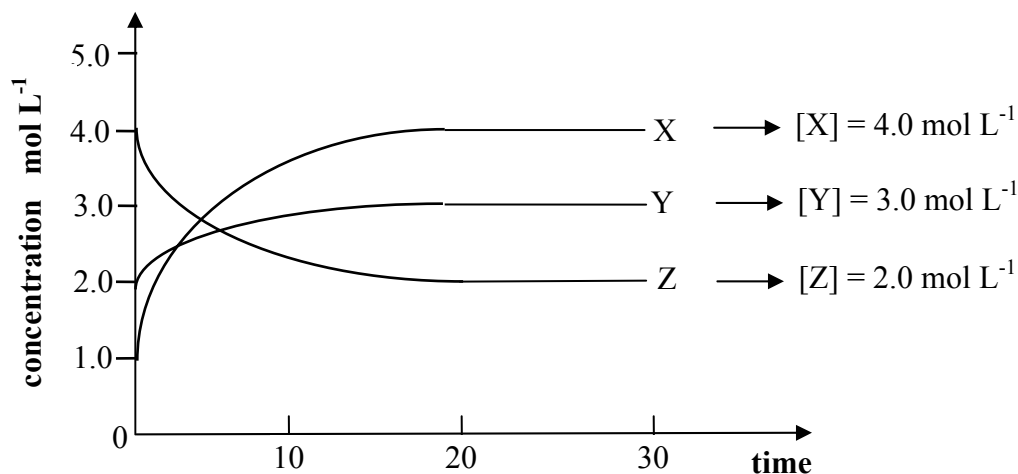
Q15. **B** The energy profile shown is for an exothermic reaction. It shows that the products, R and S, have a lower energy content than the reactants, P and Q. This means that the **products are more stable** than the reactants, as is also evidenced by the fact that the activation energy for the reverse reaction, β, is greater than the activation energy for the forward reaction, α.

Since the forward reaction is exothermic, ΔH must be less than zero, i.e. $\Delta H < 0$.

So $\mathbf{\Delta H = \alpha - \beta}$

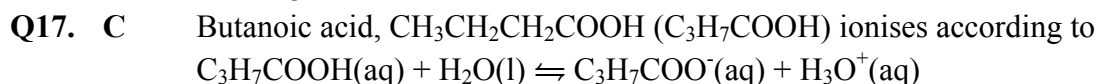**Q16. D** $2Z \rightleftharpoons 3X + Y$ $K_c = [X]^3[Y] / [Z^2]$
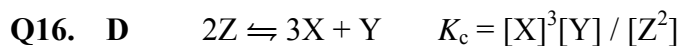
The equilibrium concentrations are obtained from the concentration-time graph.

$K_c = (4.0^3 \times 3.0) / 2.0^2$
$\quad = (64 \times 3.0) / 4.0$
$\quad = \mathbf{48}$

Q17. C   Butanoic acid, $CH_3CH_2CH_2COOH$ (C_3H_7COOH) ionises according to

$C_3H_7COOH(aq) + H_2O(l) \rightleftharpoons C_3H_7COO^-(aq) + H_3O^+(aq)$

$K_a = [C_3H_7COO^-][H_3O^+] / [C_3H_7COOH]$
Since $C_3H_7COOH(aq)$ is a weak acid, then
$[H_3O^+]_e = [C_3H_7COO^-]_e$ and
$[C_3H_7COOH]_e = [C_3H_7COOH]_{initially} = 0.00100$ M
So $1.30 \times 10^{-5} = [H_3O^+]^2 / 0.00100$
$\quad [H_3O^+]^2 \quad = 1.30 \times 10^{-5} \times 0.00100$
$\quad\quad\quad\quad = 1.30 \times 10^{-8}$
$\quad [H_3O^+] \quad = \sqrt{(1.30 \times 10^{-8})}$
$\quad\quad\quad\quad = 1.14 \times 10^{-4}$.
$pH = -\log_{10}[H_3O^+]$
$\quad = -\log_{10}(1.14 \times 10^{-4})$
$\quad = -(3.94)$
$\quad = \mathbf{3.94}$

Q18. D   According to the calibration curve

An absorbance of 0.520 corresponds to $c(Cu^{2+}) = 2.00$ mg L^{-1}
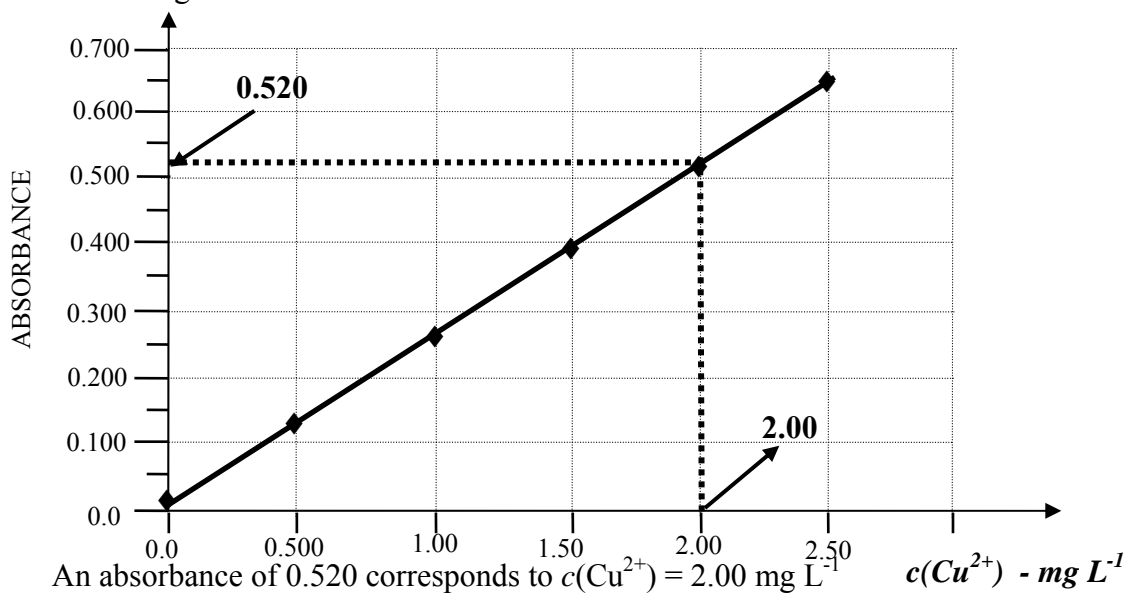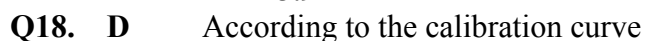
However, this is the $c(Cu^{2+})$ in the twice diluted sample of the original solution

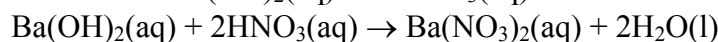The original solution was diluted twice, by a factor of 10 ($\frac{100}{10}$) and then a factor of 20 ($\frac{100}{5}$)

So the c (Cu^{2+}) in the original solution would be
2.00 x 10.x.20 = **400 mg L^{-1}**

Q19. B The pH depends on the $[H^+]$ in the resulting solution, which can be determined once which reactant, if either, is in excess.
The neutralisation between $Ba(OH)_2(aq)$ and $HNO_3(aq)$ occurs according to

$$Ba(OH)_2(aq) + 2HNO_3(aq) \rightarrow Ba(NO_3)_2(aq) + 2H_2O(l)$$

50 mL	50 mL
0.020 M	0.060 M

$n[Ba(OH)_2] = c[Ba(OH)_2]$ x $V[Ba(OH)_2]$
$\qquad = 0.020$ x 50x10^{-3}
$\qquad = 1.0$x10^{-3} mol
$n(HNO_3) = c(HNO_3)$ x $V(HNO_3)$
$\qquad = 0.060$ x 50x10^{-3}
$\qquad = 3.0$x10^{-3} mol

Identifying which reactant is in excess

$$Ba(OH)_2(aq) + 2HNO_3(aq) \rightarrow Ba(NO_3)_2(aq) + 2H_2O(l)$$
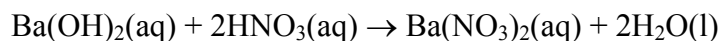
Initially (mol) 1.0 x 10^{-3} $\qquad$ 3.0 x 10^{-3}
Reacting (mol) 1.0 x 10^{-3} $\qquad$ 2.0 x 10^{-3}
Finally (mol) $\qquad$ - $\qquad\qquad$ $\underline{1.0x10^{-3}}$
$HNO_3(aq)$ is in excess in the resultant solution
$n(H^+)$ in resultant solution $= n(HNO_3)$ in excess
$\qquad\qquad\qquad\qquad\qquad = 1.0$ x 10^{-3} mol (in 100 mL of solution)
$[H^+]$ in resultant solution $= 1.0$ x 10^{-3} mol / 100x10^{-3} L
$\qquad\qquad\qquad\qquad\qquad = 0.010$ mol L^{-1}

pH $= -\log_{10}[H^+]$
$\quad = -\log_{10}(0.010)$
$\quad = -(-2.0)$
$\quad = 2.0$

Q20. B Consider the alternatives
A – HCO_3^- is amphiprotic, i.e. can act as either an acid or a base
$\qquad$ Related conjugate acid/base pairs are HCO_3^- / CO_3^{2-} and H_2CO_3 / HCO_3^-
B – these is no unsaturated hydrocarbon present
$\qquad C_5H_{12}$ – pentane – is saturated,
$\qquad C_2H_4Cl_2$ – dichloroethane – is a chloroalkane
C – $HOCH_2CH_2OH$ – 1,2-ethanediol – is a diol which will react with a diacid, e.g.
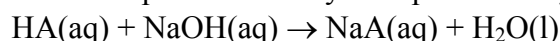$\qquad HOOCC_6H_4COOH$ to produce a polyester.
D – V_2O_5 – vanadium pentoxide / vanadium(V) oxide – is the catalyst used in the
$\qquad$ Contact process during sulfuric acid production.

Section B
Question 1
(a) The monoprotic acid may be represented by HA, so the reaction with NaOH is

$HA(aq) + NaOH(aq) \rightarrow NaA(aq) + H_2O(l)$

$n(NaOH)$ used $= c(NaOH) \times V(NaOH)$

$= 0.1000 \times 27.48 \times 10^{-3}$

$= 2.748 \times 10^{-3}$ mol

$n(HA) = n(NaOH) = 2.748 \times 10^{-3}$ mol ❶

$c(HA) = n(HA) / V(HA)$

$= 2.748 \times 10^{-3} / 25.0 \times 10^{-3}$

$= \mathbf{0.110\ M}$ ❶

(b) 1.32 g of the acid was used to produce 200 mL of solution.

$n(HA)$ in 200 mL $= c(HA) \times V(HA)$

$= 0.110 \times 200 \times 10^{-3}$

$= 0.0220$ mol ❶

Since $n(HA) = m(HA) / M(HA)$, it follows that

$M(HA) = m(HA) / m(HA)$

$= 1.32$ g $/ 0.0220$ mol

$= 60.0$ g mol^{-1} ❶

(c) Molecular formula $= (M_r / EFM) \times$ Empirical Formula

$M_r = 60.0$

$EFM =$ relative mass according to empirical formula (CH_2O)

$= 30.0$

Molecular formula $= (60.0 / 30.0) \times CH_2O$

$= 2 \times CH_2O$
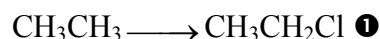
$= C_2H_4O_2$ ❶

Since each molecule contains C, H and O, and two O atoms, the acid is most likely a carboxylic acid. The carboxylic acid with 2 C atoms is **ethanoic acid**, CH_3COOH. ❶

(d) The saturated hydrocarbon is ethane, CH_2CH_3

Step 1. Ethane is converted to chloroethane by reaction with Cl_2 in UV light

$CH_3CH_3 \longrightarrow CH_3CH_2Cl$ ❶

Step 2. Chloroethane is converted to ethanol by reaction with an aqueous solution of hydroxide ions.

$CH_3CH_2Cl \xrightarrow{OH^-(aq)} CH_3CH_2OH$ ❶
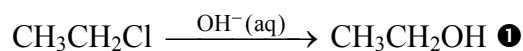
Step 3. Ethanol is oxidised to ethanoic acid by reaction with an acidified solution of dichromate ions.

$CH_3CH_2OH \xrightarrow[(aq)+^+(aq)]{CR_2O_7^{2-}} CH_3COOH$ ❶❶
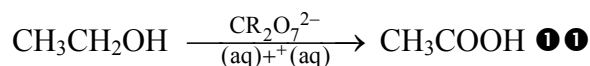
(e) 2-propyl propanoate is produced by reaction between propanoic acid and 2-propanol, in the presence of sulfuric acid according to

$CH_3CH_2COOH(l) + (CH_3)_2CHOH(l) \xrightarrow{H_2SO_4} CH_3CH_2COOCH(CH_3)_2(l) + H_2O(l)$ ❶❶
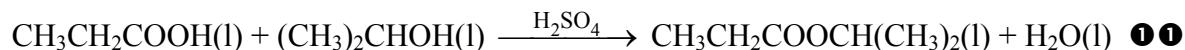
Propanoic acid contains the **carboxy (-COOH) functional group** which reacts with the **hydroxyl (-OH) functional group** to form the **ester (-COO) functional group**. **Sulfuric acid** acts as a **catalyst** for the reaction. ❶
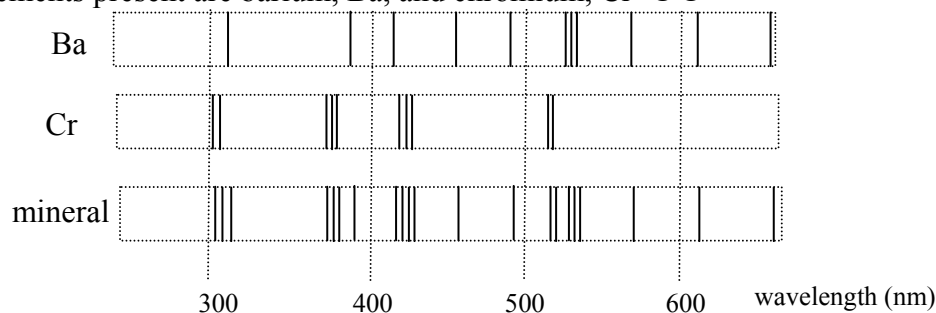
Question 2.

(a)   (i)   The reaction $S(l) + O_2(g) \rightarrow SO_2(g)$ occurs in the burner. ❶

      (ii)   The oxidation state of **S changes from 0 to + 2** whilst the oxidation state of O **changes from 0 to -2**. ❶

      (iii)   The reaction $S(l) + O_2(g) \rightarrow SO_2(g)$ may be classified as a **redox** reaction or a **combustion** reaction. ❶

(b)   (i)   The conversion of SO_2 to SO_3 occurs in the converter. ❶

      (ii) $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ ❶

      (iii)   The reaction is **exothermic**.
Since the forward reaction is exothermic this reaction and the **yield of SO_3 is favoured by low temperature** ❶. However **low temperatures decrease the rate of reaction.** ❶ Conditions used reflect a **compromise** situation for this rate / yield conflict; **450°C** is still low enough to provide a very good yield; a **catalyst (V_2O_5)** is used to speed up the rate of reaction. ❶

      (iv)   **Le Chatelier's principle** suggests that an equilibrium system will react to a change in conditions by moving to oppose the change. Hence, the **yield of SO_3 would be increased at higher pressures** because the system will oppose a pressure increase by moving the position of equilibrium in favour of the side with fewer particles. ❶ However, because the **yield of SO_3 is very good at atmospheric pressure** the costs of maintaining higher pressures are not justified and so low pressures (100-200 kPa) are used. ❶

(c)   (i)   The SO_3 is converted to H_2SO_4 in the **absorber / diluter**. ❶

      (ii) $SO_3(g) + H_2SO_4(l) \rightarrow H_2S_2O_7(l)$ ❶
$H_2S_2O_7(l) + H_2O(l) \rightarrow 2H_2SO_4(l)$ ❶

      (iii)   Reaction between $SO_3(g)$ and $H_2O(l)$ is very **exothermic** and an **acid fog** (mist) is created which is quite hazardous and the conversion is very inefficient. ❶

      (iv)   There is **no change in oxidation number**. The oxidation number of S is +6 in SO_3, $H_2S_2O_7$ and H_2SO_4, and the oxidation numbers of H and O remain at +1 and -2 respectively throughout the conversions. ❶

Question 3

(a)   An emission spectrum of an element is produced when **electrons**, having previously been excited to higher energy levels by absorbing energy, **emit energy as they return from higher energy levels to lower energy levels**. Each line on an emission spectrum corresponds to the energy difference between two specific energy levels. As **atoms emit amounts of energy equal to these energy differences**, these correspond to **specific wavelengths** of light and produce **lines corresponding to those wavelengths** on the emission spectrum. ❶❶
Because each element has a **different number of electrons**, **each element emits light with a unique set of energy differences** and wavelengths and hence a unique set of lines in its emission spectrum. ❶

(b)   If an element is present in the mineral, each line in its emission spectrum must be present in the emission spectrum of the mineral.
The elements present are barium, Ba, and chromium, Cr ❶❶

(c)   Atomic absorption spectroscopy (AAS). ❶
       refer discussion relating to Question 13 in Section A.

Question 4.
(a) n(NaOH) = m(NaOH) / M(NaOH)
              = 5.623 g / 40.0 g mol^{-1}
              = 0.1406 mol
       c(NaOH) = n(NaOH) / V(NaOH)
              = 0.1406 mol / 250x10^{-3} L
              = **0.562 mol L^{-1}** ❶
(b)   Solid **NaOH absorbs water from the atmosphere**. Therefore, the weighed sample of
       NaOH contains a small amount of water and the **actual n(NaOH)** present in the sample
       will be **less than** that **calculated** from the measured mass. Consequently, the actual
       concentration should be lower than the calculated concentration. ❶
       NaOH(aq) will also react with atmospheric CO_2, according to
       $2NaOH(aq) + CO_2(g) \rightarrow Na_2CO_3(aq) + H_2O(l)$.
(c)   Since we are analysing a base, the primary standard would be expected to be an **acid**. ❶
(d)   (i) $H_2C_2O_4(aq) + 2NaOH(aq) \rightarrow Na_2C_2O_4(aq) + 2H_2O(l)$ *or*
             $H_2C_2O_4.2H_2O(aq) + 2NaOH(aq) \rightarrow Na_2C_2O_4(aq) + 4H_2O(l)$ ❶
       (ii) n(H$_2$C$_2$O$_4$.2H$_2$O) used to make solution = m(H$_2$C$_2$O$_4$.2H$_2$O) / M(H$_2$C$_2$O$_4$.2H$_2$O)
                                       = 2.054 g / 126 g mol^{-1}
                                       = 0.0163 mol

             n(H$_2$C$_2$O$_4$) in 100 mL solution   = n(H$_2$C$_2$O$_4$.2H$_2$O)
                                        = 0.0163 mol ❶
             n(H$_2$C$_2$O$_4$) in 25.0 mL aliquot   = (0.0163 / 100   ) x 25
                                        = 0.004075 mol ❶
             n(NaOH) reacting   = 2 x n(H$_2$C$_2$O$_4$)
                                        = 2 x 0.004075
                                        = 8.15x10^{-3} mol ❶
             c(NaOH)   = n(NaOH) / V(titre)
                                        = 8.15x10^{-3} mol / 18.41x10^{-3} L
                                        = **0.443 mol L^{-1}** ❶

Question 5.
(a)   High Performance Liquid Chromatography (HPLC) ❶
       The open solvent container, the pump and the short column were useful clues.
(b)   Gas Chromatography (GC) or Gas-Liquid Chromatography (GLC) ❶
(c)   In HPLC the **mobile phase is a liquid**, and **stationary phase is a solid** (or solid coated
       with a liquid) **packed into the column as fine particles** to increase surface area. ❶
       In GC, the **mobile phase is a gas** and the **stationary phase is a high boiling point
       liquid** coating the interior surface of the column. ❶
       In all chromatography, the mobile phase carries the mixture being separated across the
       stationary phase. ❶   The different components of the mixture are separated according to
       their relative attractions to the stationary phase. ❶
(d)   (i)   **Retention time** is used to identify components separated by column
             chromatography. A high retention time indicates the component was **more
             strongly attracted to the stationary phase** and took longer to elute from the
             column ❶

(ii)   **R_F values** (retardation factors) are used to identify components separated by paper chromatography. ❶ The R_F value of a particular component is determined by measuring the **distance travelled by the component from the origin** and **dividing by** the **distance travelled by the solvent front from the origin**. ❶

(iii)   A **higher retention time** results from **stronger attraction to the stationary phase**. With respect to R_F **values**, the **stronger the attraction to the stationary phase**, the shorter the distance moved by the component relative to the distance travelled by the mobile phase and the **smaller the R_F value.** ❶

Question 6.

(a)   An **increase in pH**, i.e. decrease in $[H_3O^+]$ will cause the **position of equilibrium**

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

to **shift** to the **right** to compensate for the loss of H_3O^+. ❶

A **decrease in pH**, i.e. increase in $[H_3O^+]$ will cause the **position of equilibrium** to **shift** to the **left** to use up some of the added H_3O^+. ❶

(b) $CO_2(g) \rightleftharpoons CO_2(aq)$ 1.

$CO_2(aq) + H_2O(l) \rightleftharpoons H_2CO_3(aq)$ 2.

$H_2CO_3(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + HCO_3^-(aq)$ 3.

The decrease in blood pH, due to an increase in $[H_3O^+]$, cause **equilibrium 3.** to **shift** to the **left** thus **increasing** the **$[H_2CO_3]$.** This then impacts on **equilibrium 2.** causing it to **shift** to the **left** thus **increasing** the **$[CO_2(aq)]$**. This then impacts on **equilibrium 1.** causing it to **shift left increasing** the **amount of $CO_2(g)$** in the lungs. ❶ The faster and deeper breathing response removes the CO_2 and enables the pH of the blood to be maintained within the required range. ❶

(c)   Low O_2 concentration will cause the position of the equilibrium

$HbH^+ + O_2 \rightleftharpoons HbO_2 + H^+$

to shift to the left releasing O_2 into the tissue. This causes the $[H^+]$ to decrease and consequently the **pH** to **increase.** ❶

(d)   Carbon monoxide binds to haemoglobin more strongly than O_2 and takes the place of O_2 molecules in the oxyhaemoglobin complex according to the equilibrium reaction:

$HbO_2 + CO \rightleftharpoons HbCO + O_2$

Oxygen transport around the body is reduced. ❶

Question 7.

(a)   **Heptane**.

Both heptane, C_7H_{16} and hexane, C_6H_{14} are non-polar compounds. Hence, the bonding between molecules is **dispersion force attraction**. Since the strength of dispersion force attraction depends on **molecule size, heptane** will have the **stronger intermolecular attraction** and the **higher boiling temperature**. ❶

(b) $CH_3(CH_2)_8CH_3(g) \rightleftharpoons CH_3CH_2CH=CH_2(g) + CH_3CH=CHCH_3(g) + CH_3CH_3(g)$ ❶❶

      decane   *1-butene*   *2-butene*   *ethane*

(c)   Cracking is an **endothermic** process. So the **yield** of products is **favoured by higher temperatures**. In addition, **reaction rates increase with increasing temperature** as the proportion of fruitful collisions increases. ❶

(d)   **Alkanes** – used as **fuels**, e.g. octane in petrol ❶

      Alkenes – use to produce a **variety of derived chemicals** via addition reactions, e.g. ethanol and polyethylene from ethene. ❶