1995

CHEMISTRY

UNIT 3

TRIAL EXAM

CHEMISTRY ASSOCIATES
P.O. BOX 2227
KEW, VIC., 3101
AUSTRALIA
TEL:(03) 9817 5374 FAX: (03) 9817 4334

email: chemas@vicnet.net.au

Internet: http://www.vicnet.net.au/~chemas/education.htm

VCE CHEMISTRY 1995

CAT 1: Chemistry and the market place

SECTION A. MULTIPLE CHOICE ANSWER SHEET

How to complete this form

Please use an **HB PENCIL** only.
If you make a mistake, **ERASE** the incorrect answer.
DO NOT just cross it out.

EXAMPLE ONLY

9	**1**	**9**	**1**	**0**	**9**	**1**	**0**	**E**
0	0	0	0	0	0	0	0	A
1	1	1	1	1	1	1	1	E
9	9	9	9	9	9	9	9	X

Enter your Student Number (if one is provided) in the box below as shown in the example above

ONLY mark ONE box per line.

STUDENT NUMBER

0	0	0	0	0	0	0	0	A
1	1	1	1	1	1	1	1	E
2	2	2	2	2	2	2	2	F
3	3	3	3	3	3	3	3	G
4	4	4	4	4	4	4	4	J
5	5	5	5	5	5	5	5	L
6	6	6	6	6	6	6	6	R
7	7	7	7	7	7	7	7	T
8	8	8	8	8	8	8	8	W
9	9	9	9	9	9	9	9	X

PLEASE TURN OVER

1995 CHEMISTRY TRIAL CAT 1 **CHEMISTRY ASSOCIATES**

SECTION A.

MULTIPLE CHOICE ANSWER SHEET

ABSENT

SURNAME
GIVEN NAME(S)

Instructions

Answer **ALL** the questions.

Marks will **NOT** be deducted for incorrect answers.

NO mark will be given if more than **ONE** answer is completed for any question.

USE HB PENCIL ONLY.

All answers must be completed like this.

A	B	C	D

One answer per line

1	A	B	C	D
2	A	B	C	D
3	A	B	C	D
4	A	B	C	D
5	A	B	C	D
6	A	B	C	D
7	A	B	C	D
8	A	B	C	D
9	A	B	C	D
10	A	B	C	D

One answer per line

11	A	B	C	D
12	A	B	C	D
13	A	B	C	D
14	A	B	C	D
15	A	B	C	D
16	A	B	C	D
17	A	B	C	D
18	A	B	C	D
19	A	B	C	D
20	A	B	C	D

Please DO NOT fold, bend or staple this form

DETACH THIS ANSWER SHEET AT THE START OF THE EXAMINATION

STUDENT NUMBER _____

VICTORIAN CERTIFICATE OF EDUCATION 1995

CHEMISTRY

COMMON ASSESSMENT TASK 1 (TRIAL)

Chemistry and the market place

(not to be used before Monday May 22, 1995)

Reading time: 15 minutes

Total writing time: 1 hour 30 minutes

QUESTION AND ANSWER BOOKLET

Structure of booklet

Section	Number of questions	Number of questions to be answered
A	1 (20 items)	1 (20 items)
B	5	5

Directions to students

Materials

Question and answer booklet of 18 pages, and a data page on the back of this sheet.

Answer sheet for multiple-choice items. You should have at least one HB pencil and an eraser.

An approved calculator may be used.

The task

Please ensure that you write your **student number** in the space provided on this booklet and your **name and student number** in the space provided on the answer sheet for multiple-choice items.

Answer **all** items from Section A.

Section A items should be answered on the multiple-choice answer sheet provided.

Answer **all** questions from Section B.

Section B questions should be answered in this booklet in the spaces provided following each question.

There is a total of 67 marks available.

There is provision for rough working throughout the booklet

All written responses should be in English.

At the end of the task

Place the multiple-choice answer sheet inside the back cover of this booklet and hand them in.

1995 CHEMISTRY TRIAL CAT 1

DATA

TABLE 1: RELATIVE ATOMIC MASS ($^{12}C = 12.00$)

Element	Symbol	Atomic No.	Relative Atomic Mass
Carbon	C	6	12.0
Chlorine	Cl	17	35.5
Iron	Fe	26	55.9
Hydrogen	H	1	1.0
Magnesium	Mg	12	24.3
Nitrogen	N	7	14.0
Sodium	Na	11	23.0
Oxygen	O	8	16.0
Sulfur	S	16	32.1

TABLE 2: PHYSICAL CONSTANTS

Ideal gas molar volume of gas at SLC (298 K, 101.3 kPa) = 24.5 L mol^{-1}

Gas Constant, R = 8.31 J K^{-1} mol^{-1}

Ionisation constant of water , K_w, at 298 K = 1.0×10^{-14} M^2

SECTION A

SPECIFIC INSTRUCTIONS FOR SECTION A

Section A, Question 1, consists of 20 multiple choice items and is worth 20 marks and therefore about 30% of the total marks available for this examination.

You should therefore spend about 27 minutes on Section A.

Choose the response that is **correct** or **best answers the question**, and mark your choice on the multiple-choice answer sheet according to the instructions on that sheet.

A correct answer scores 1, an incorrect answer scores 0. No credit will be given for an item if two or more letters are marked for that item. Marks will **not** be deducted for incorrect answers and you should attempt every item.

Question 1

Item 1
A mixture of water soluble colours **K1** and **K2** is separated using paper chromatography.
The R_f value of component **K1** is 0.25 and the R_f value of component **K2** is 0.75.
When the solvent has moved a distance of 10 cm, the distance separating **K1** and **K2** will be

A. 2.5 cm.

B. 3.0 cm.

C. 5.0 cm.

D. 7.5 cm.

Item 2
Which one of the following is a property of an oil in water emulsion?

A. It mixes readily with oil.

B. The electrical activity is lower than that of a water in oil emulsion.

C. It feels greasy on the fingers.

D. It can be coloured by adding a water soluble dye.

Item 3
Which one of the following is an anionic detergent?

A. $CH_3(CH_2)_{13}C_6H_4SO_3^-$

B. $CH_3(CH_2)_9N^+(CH_3)_3$

C. Na_2CO_3

D. K_2SO_4

SECTION A

Item 4

In an acid-base titration, a 50 cm^3 burette is filled with 0.0500 M H_2SO_4. An approximately 0.05 M solution of sodium carbonate (Na_2CO_3) is to be added to the titration flask using a pipette so that the exact concentration of the sodium carbonate solution can be determined by titration.
Which one of the following volumes should **not** be used in the pipette?

A. 20 cm^3

B. 25 cm^3

C. 30 cm^3

D. 50 cm^3

Item 5

In a separate experiment, 30.25 cm^3 of 0.0500 M H_2SO_4 was required to react exactly with 24.5 cm^3 of Na_2CO_3. The concentration of the Na_2CO_3 is

A. 0.031 M

B. 0.062 M

C. 0.092 M

D. 0.122 M

Item 6

The concentration of OH^- in a solution is 10^{-3} M. The pH of this solution is

A. 3

B. 7

C. 9

D. 11

Item 7

250 mL of 0.500M NaOH(aq) is reacted with 125 mL of 0.500 M H_2SO_4(aq). The pH of the resultant solution is

A. 3

B. 7

C. 9

D. 11

SECTION A

Items 8 and 9 refer to the following information.

A pain relieving tablet with a mass of 0.8 g contains 250 mg of aspirin $C_9H_8O_4$ (M_r = 180). The tablet is dissolved in 150 mL of water to produce a homogeneous solution.

Item 8
The amount, in mole, of aspirin in the 150 mL of water is

A. 1.39×10^{-3} mol.

B. 4.4×10^{-3} mol.

C. 1.39 mol.

D. 4.4 mol

Item 9
The concentration of aspirin, in mol L^{-1}, in 50 mL of this solution is

A. 0.003

B. 0.009

C. 0.028

D. 0.093

Item 10
Which one of the following statements about the hydrocarbons, ethane and ethene is true?

A. ethane and ethene are both unsaturated molecules.

B. ethane is far more reactive than ethene.

C. ethane has a lower relative molecular mass than ethene.

D. ethane and ethene burn in excess air to produce carbon dioxide and water.

Item 11
Which one of the following could **not** be produced from ethene by a single step chemical reaction ?

A. ethanol

B. propene

C. ethane

D. polyethene

SECTION A

The following information refers to items 12 and 13

Acidified potassium permanganate, $KMnO_4$, can be used to oxidise methanol to formic acid in the laboratory according to the partial equations:

(1) $MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightarrow Mn^{2+}(aq) + 4H_2O(l)$

(2) $CH_3OH(aq) + H_2O(l) \rightarrow HCOOH(aq) + 4H^+(aq) + 4e^-$

Item 12
The element being reduced in this reaction **and** the change in oxidation number of the element is

A. manganese; +7 to +2

B. manganese; +3 to +2

C. carbon; -2 to 0

D. carbon; +4 to +2

Item 13
The number of mole of methanol that will be oxidised to formic acid by 0.005 mole of potassium permanganate is

A. 3.13×10^{-3} mol.

B. 4.00×10^{-3} mol.

C. 5.00×10^{-3} mol.

D. 6.25×10^{-3} mol.

SECTION A

Item 14
The name of the molecule with the structure

$$CH_2=CHCH_2CH_2CH_2CH_3$$

is

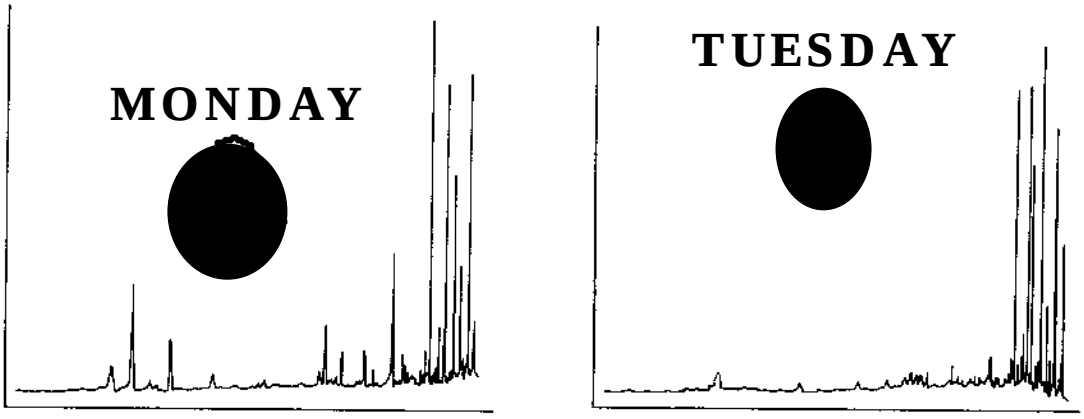
A. 1-hexene.

B. 1-hexane.

C. 2-hexene.

D. 2-hexane.

Item 15
A particular sample of a chemical was analysed with an atomic absorption spectroscope on Monday. The sample was then stored overnight and analysed again on Tuesday. The results of the Monday analysis and the Tuesday analysis are shown below.



These graphs show that the chemical sample

A. did not change overnight because the large peaks are still present.

B. did not change overnight because the large peaks are still on the right.

C. did change overnight because the pattern of peaks is different.

D. did change overnight because the pattern of peaks is the same.

The following information refers to items 16 and 17

A small amount of the catalyst manganese dioxide, MnO_2, is added to a solution of hydrogen peroxide, H_2O_2 , under standard laboratory conditions (SLC). Water (H_2O) and oxygen gas (O_2) are produced in the reaction.

Item 16
If 1 mole of hydrogen peroxide reacts completely, the volume of oxygen gas produced is

A. 12.25 L.

B. 24.5 L.

C. 36.75 L.

D. 49.0 L

Item 17
The purpose of the manganese dioxide in this reaction is to

A. increase the amount of oxygen gas produced.

B. increase the rate at which oxygen gas is produced.

C. decrease the amount of oxygen gas produced.

D. decrease the rate at which oxygen gas is produced.

WORKING SPACE

The following information refers to items 18 and 19

Ammonia gas is produced industrially in a reversible reaction involving nitrogen gas and hydrogen gas according to the equation $N_2(g) + 3H_2(g) \Leftrightarrow 2NH_3(g)$. The equilibrium constant for this reaction at 400 ^oC is 0.052 M^{-2}. The reaction to produce ammonia gas is exothermic.

Item 18
If 1 mole of hydrogen gas is added to an equilibrium mixture of nitrogen gas, hydrogen gas and ammonia gas, then when equilibrium has been re-established at 400 ^oC, the amount of hydrogen gas in the new equilibrium mixture will be

A. less than in the original equilibrium mixture.

B. the same as in the original equilibrium mixture.

C. greater than in the original equilibrium mixture.

D. unable to be determined from the information provided.

Item 19
If the temperature of the equilibrium mixture is increased to 500^oC, the value of the equilibrium constant will be

A. less than 0.052 M^{-2}.

B. equal to 0.052 M^{-2}.

C. greater than 0.052 M^{-2}.

D. unable to be determined from the information provided.

Item 20
Polystyrene is a polymer used in the packaging industry.
The formula of polystyrene is $\{-CH_2CH\ (C_6H_5)-\}_n$
The monomer for this polymer has the molecular formula

A. C_8H_6

B. C_8H_7

C. C_8H_8

D. C_8H_9

END OF SECTION A

SPECIFIC INSTRUCTIONS FOR SECTION B

Section B consists of five short-answer questions (questions 2 to 6 inclusive). You must answer all these questions. This section is worth 47 marks or approximately 70% of the total. You should spend approximately 62 minutes on this section.

The marks allotted to each question and suggested times are indicated at the end of the question.

Questions should be answered in the spaces provided in this booklet.

To obtain full credit for your responses you should

- give simplified answers with an appropriate number of significant figures to all numerical questions; unsimplified answers will not be given full credit.
- show all working in your answers to numerical questions. No credit can be given for an incorrect answer unless it is accompanied by details of the working.
- make sure chemical equations are balanced and that the formulas for individual substances include an indication of state, {for example $H_2(g)$; NaCl(s)}

Question 2

The vitamin C industry is a very large commercial enterprise in the 1990's. Manufacturers of vitamin C tablets must maintain strict control of the quality of the product by randomly selecting tablets from each production run for analysis. One method of analysis uses iodine in the reaction shown below.

$$I_2(aq) + C_6H_8O_6(aq) = 2I^-(aq) + 2H^+(aq) + C_6H_6O_6(aq)$$

ascorbic acid

Two tablets of total mass 0.400 g containing ascorbic acid (vitamin C) (M_r = 176) were dissolved in 100 mL of water in a volumetric flask. Three 20.0 mL aliquots of this solution were transferred to conical flasks and titrated with 0.020 mol L^{-1} iodine solution from a burette.
The average titre was 15.25 mL.

a. Identify the oxidant in this reaction. Give a reason for your choice.

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_____

Question 2 (continued)

b. What was the average number of mole of iodine used in the titration?

c. What was the molar concentration of the ascorbic acid in the volumetric flask?

d. What was the average mass of ascorbic acid in each tablet?

e. What was the average percentage of ascorbic acid in each tablet?

Question 2 (continued)

f. Starch is used as an indicator in these titrations. Starch turns dark blue-black in the presence of iodine. What colour change would indicate the end-point of the titration?

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1+1+2+2+1+2 = 9 marks
(suggested time = 12 minutes)

Question 3
The mineral haematite, present in iron ore, is a valuable material mined in huge quantities in Australia to be turned into the metal iron. At the same time, millions of dollars are spent each year to prevent iron from turning to rust.

a. What do haematite and rust have in common?

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b. What substances must be present in order that corrosion of iron should occur most rapidly? Write an equation for the oxidation of iron.

_____

_____

_____

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_____

Question 3 (continued)

c. What is the name and chemical formula of the solid reductant added to the blast furnace with haematite?

d. Although iron oxides are reduced in the blast furnace to metallic iron, one of the raw materials used in the process is oxygen, O_2, from the air. Use a chemical equation to explain the use of oxygen in the blast furnace.

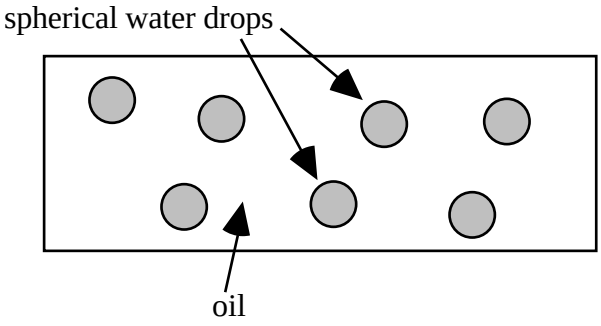
e. Describe why limestone is added to the blast furnace in the production of iron. Include appropriate equations in your answer.

f. Write a balanced chemical equation for the reaction between iron and hydrochloric acid.

2+2+1+2+2+1 = 10 marks
(suggested time = 13 minutes)

SECTION B

Question 4
When water is injected into an oil of equal density, it adopts a perfectly spherical shape as shown in the diagram below



a. Use the idea of surface energy to explain why water has this spherical shape.

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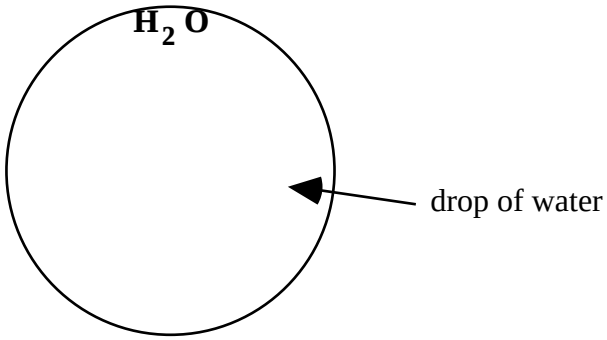
b. Draw the forces acting on the water molecule shown in the diagram below.

this water molecule is on the surface of the drop



c. What happens to the surface energy of water when a detergent is added?

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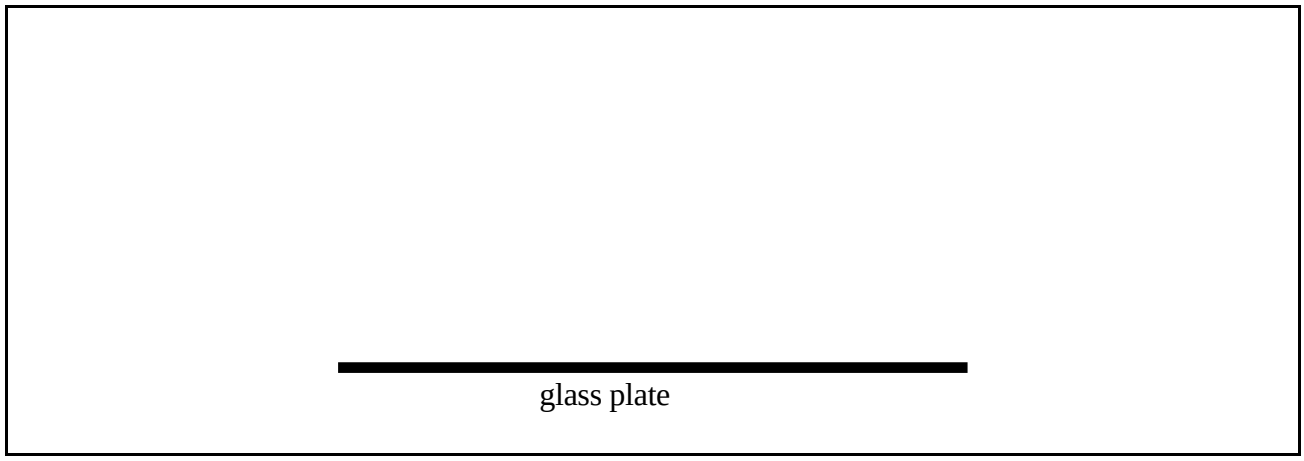
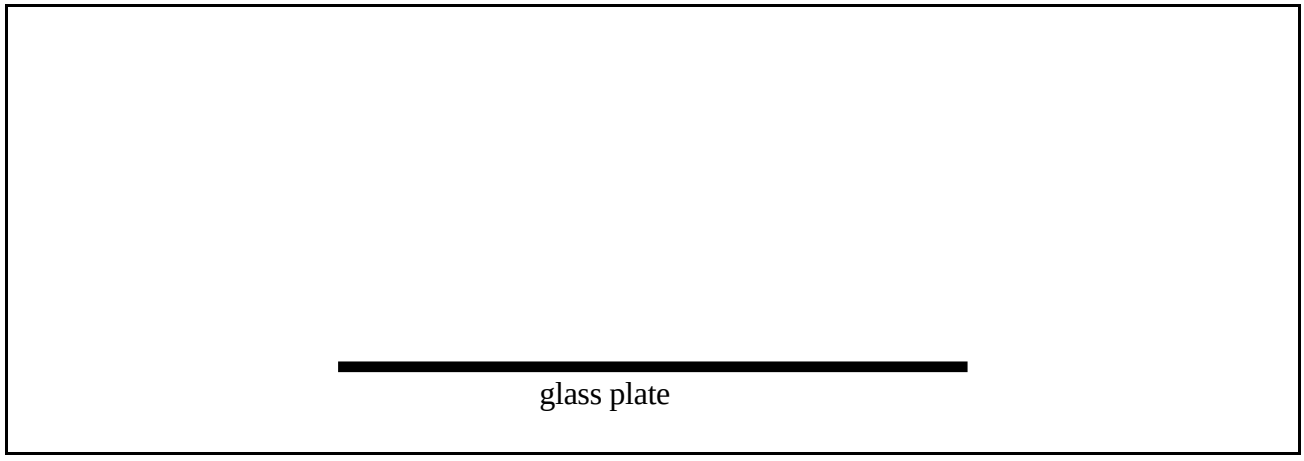
Question 4 (continued)

d. Draw a fully labelled diagram showing the forces acting on a drop of water resting on a glass plate.



e. Draw a fully labelled diagram showing the forces acting on a drop of mercury resting on a glass plate.



Question 4 (continued)

f. Use your diagrams in **d.** and **e.** to explain why water wets a glass surface while mercury does not wet a glass surface.

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2+2+2+2+2+2 = 12 marks
(suggested time = 16 minutes)

WORKING SPACE

SECTION B

Question 5

One of the many chemicals found in swimming-pool water is the weak acid, HClO, hypochlorous acid. HClO exists in equilibrium according to the reversible equation

$$HClO(aq) \Leftrightarrow H^+(aq) + ClO^-(aq).$$

This equation has an equilibrium constant of 5.0×10^{-8} at 298 K.

In a 100 mL sample of swimming-pool water at 298 K, the concentration of hypochlorous acid is found to be 5.0×10^{-8} mol L^{-1}. The pH of the water is measured as 6.7

a. What is the equilibrium constant expression for the ionisation of hypochlorous acid?

b. How many mole of hypochlorous acid is present in the sample?

c. What is the hydrogen ion concentration in the sample?

Question 5 (continued)

d. What is the concentration of hypochlorite ions in the pool water?

_____

_____

_____

_____

_____

e. What would happen to the concentration of hypochlorite ions if the pH of the pool water were raised to 7.8?

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_____

2+1+1+2+2 = 8 marks
(suggested time = 10 minutes)

SECTION B

Question 6

a. Write the name and chemical formula of a naturally occurring element which can be used as a starting point for the manufacture of sulfuric acid.

b. Write a balanced chemical equation for the production of sulfur dioxide from the substance you have named in **a.**

c. Sulfur dioxide can be oxidised to sulfur trioxide.
The equation which best describes this oxidation is:

$2SO_2(g) + O_2(g) \Leftrightarrow 2SO_3(g)$; $\Delta H = -99$ kJ mol^{-1}.

Discuss the factors of reaction rate and equilibrium yield of SO_3 which are must be considered in the industrial application of this reaction.

Question 6 (continued)

d. Write a balanced equation for the reaction between sulfur trioxide and water to give sulfuric acid.

_____

_____

e. In the industrial process, sulfur trioxide is not reacted directly with water to produce sulfuric acid. Describe the method used and the reason for this method.

_____

_____

_____

_____

_____

1+1+3+1+2 = 8 marks
(suggested time = 11 minutes)

END OF QUESTION AND ANSWER BOOKLET

1995 CHEMISTRY TRIAL CAT 1

CHEMISTRY ASSOCIATES
P.O. BOX 2227
KEW, VIC., 3101
AUSTRALIA
TEL:(03) 9817 5374 **FAX: (03) 9817 4334**

SUGGESTED SOLUTIONS **SECTION A**

Question 1

Item 1 ANS C

The R_f value is defined as $\frac{\text{distance moved by the component}}{\text{distance moved by the solvent}}$.
Hence, when the solvent has moved 10 cm, colour **K1** will have moved 2.5 cm and colour **K2** will have moved 7.5 cm. Hence, the distance separating **K1** and **K2** will be 5.0 cm.

Item 2 ANS D

An oil in water emulsion will accept a water soluble dye for colouring purposes. It does not mix with oil, has a higher electrical conductivity than a water in oil emulsion and is non-greasy and cool on the skin.

Item 3 ANS A

An anion is a negatively charged ion. $CH_3(CH_2)_{13}C_6H_4SO_3^-$ is an anion. It has a long non-polar hydrocarbon end at the other end of the molecule. It is an anionic detergent.

Item 4 ANS D

The balanced equation for the reaction is
$H_2SO_4(aq) + Na_2CO_3(aq) = Na_2SO_4(aq) + H_2O(l) + CO_2(g)$.
Notice that 1 mole of sulfuric acid reacts exactly with 1 mole of sodium carbonate.
The concentration of the sodium carbonate is **approximately** 0.05 M. If a volume of 50 cm^3 were used in the pipette, more than 50 cm^3 of sulfuric acid **might** be required to reach the end-point. The burette would then need to have more sulfuric acid added to complete the titration.
This would introduce a significant error into the titration.

Item 5 ANS B

From the balanced chemical equation
$H_2SO_4(aq) + Na_2CO_3(aq) = Na_2SO_4(aq) + H_2O(l) + CO_2(g)$,
$n(Na_2CO_3) = n(H_2SO_4) = 0.0500 \times 0.03025$.
Hence, $c(Na_2CO_3) = \frac{0.0500 \times 0.03025}{0.0245} = 0.0617$ M

Item 6 ANS D

The hydrogen ion concentration = $[H^+] = \frac{10^{-14}}{[OH^-]} = \frac{10^{-14}}{10^{-3}} = 10^{-11}$. Hence, pH = 11

SUGGESTED SOLUTIONS **SECTION A**

Question 1 (continued)

Item 7 ANS B
The balanced equation for the reaction is $2NaOH(aq) + H_2SO_4(aq) = Na_2SO_4(aq) + 2H_2O(l)$.
Hence, n(NaOH) reacting = 2 x n(H_2SO_4) reacting.
n(NaOH) = 0.500 x 0.250 = 0.125. n(H_2SO_4) = 0.500 x 0.125 = 0.0625.
These are in the correct ratio for complete reaction of all the NaOH and all the H_2SO_4.
$Na_2SO_4(aq)$ is a neutral solution. Hence, the pH = 7

Item 8 ANS A
$n(\text{aspirin}) = \frac{m}{M_r} = \frac{0.25}{180} = 0.001388 = 1.39 \times 10^{-3}$ mol.

Item 9 ANS B
The concentration of aspirin in 50 mL is the same as the concentration of aspirin in 150 mL.
Hence, $c = \frac{n}{V} = \frac{1.39 \times 10^{-3}}{0.15} = 0.00925 \approx 0.009$

Item 10 ANS D
Ethane and ethene burn in excess air to produce carbon dioxide and water according to the following equations.

$2C_2H_6(g) + 7O_2(g) = 4CO_2(g) + 6H_2O(g)$

$C_2H_4(g) + 3O_2(g) = 2CO_2(g) + 2H_2O(g)$

Item 11 ANS B
Ethanol, ethane and polyethene can all be produced directly from ethene. Propene (C_3H_6) has an additional carbon atom and would be difficult to produce from ethene.

Item 12 ANS A
The oxidation number of Mn in MnO_4^- is +7. The oxidation number of Mn in Mn^{2+} is +2.
Hence, Mn has been reduced from +7 to +2.

Item 13 ANS D
There are five electrons in partial equation (1) and four electrons in partial equation (2). To balance these electrons multiply equation (1) by 4 and equation (2) by 5. Hence, 4 mole of MnO_4^- will react exactly with 5 mole of CH_3OH.
Hence, $n(CH_3OH) = \frac{5}{4} \times n(MnO_4^-) = \frac{5}{4} \times 0.005 = 0.00625 = 6.25 \times 10^{-3}$ mol.

Item 14 ANS A
There are six carbon atoms in this molecule and one double bond. Therefore, the molecule is hexene. The double bond joins carbon 1 with carbon 2. Hence, this molecule is called 1-hexene or sometimes hex-1-ene.

SUGGESTED SOLUTIONS **SECTION A**

QUESTION 1 (continued)

Item 15 ANS C
The pattern of peaks is the fingerprint of a molecule or mixture of molecules. If the pattern is different, then it cannot be the same molecule or mixture of molecules. Therefore, either the sample has been contaminated overnight or has undergone some chemical reaction.

Item 16 ANS A
The balanced chemical equation for the reaction is $2H_2O_2(l) = 2H_2O(l) + O_2(g)$.
Hence, $n(O_2)$ produced $= \frac{1}{2}$ x $n(H_2O_2)$ reacting $= \frac{1}{2}$ x 1 = 0.5.
Hence, $V(O_2)$ produced under SLC = 0.5 x 24.5 = 12.25 L.

Item 17 ANS B
A catalyst does not change the position of equilibrium in a reaction. Manganese dioxide increases the rate at which the oxygen is produced. It speeds up the reaction.

Item 18 ANS C
When the 1 mole of hydrogen gas is added to the equilibrium mixture, nitrogen and hydrogen react to produce more ammonia. At the new equilibrium position, the number of mole of nitrogen is less than the original amount and the number of mole of ammonia is greater than the original amount. Hence, the number of mole of hydrogen must be **greater than the original amount** because the equilibrium constant is constant at the same temperature.

Item 19 ANS A
Since the forward reaction is exothermic, an increase in temperature will decrease the value of the equilibrium constant.

Item 20 ANS C
Polystyrene is produced by addition polymerisation from the monomer. Hence, the molecular formula of the monomer is the same as the repeating unit in the polymer. Adding up the atoms gives C_8H_8.

SUGGESTED SOLUTIONS **SECTION B**

Question 2

a. The oxidant is iodine $I_2(aq)$. The $I_2(aq)$ has been reduced from an oxidation state of 0 to an oxidation state of -1 in $I^-(aq)$.

b. Average $n(I_2) = c \times V = 0.020 \times 0.01525 = 0.000305 = 3.05 \times 10^{-4}$ mol. **ANS**

c. From the balanced equation, number of mole of ascorbic acid in 20 mL aliquots = number of mole of iodine = 3.05×10^{-4}.
Concentration of ascorbic acid in volumetric flask (100 mL)
= concentration of ascorbic acid in 20 mL aliquots = $\frac{n}{V} = \frac{3.05 \times 10^{-4}}{0.02}$
$= 0.01525 = 1.525 \times 10^{-2}$ mol L^{-1}. **ANS**

d. Number of mole of ascorbic acid in volumetric flask = $3.05 \times 10^{-4} \times \frac{100}{20}$
Mass of ascorbic acid in volumetric flask = $3.05 \times 10^{-4} \times 5 \times 176 = 0.2684$ g.
Average mass of ascorbic acid in each tablet = $\frac{0.2684}{2} = 0.1342$ g = 134 mg **ANS**

e. Average percentage of ascorbic acid in each tablet = $\frac{134}{200} \times 100 = 67\%$ **ANS**

f. The colour change that would indicate the end-point is the faintest possible permanent blue-black colour in the conical flask.

SUGGESTED SOLUTIONS **SECTION B**

Question 3

a. Haematite has the formula Fe_2O_3 with iron in the +3 oxidation state. Rust has the general formula $Fe_2O_3.xH_2O$ also with iron in the +3 oxidation state.

b. Oxygen , water and a conducting electrolyte such as NaCl(aq) contribute to the corrosion of iron. One possible equation is

$$4Fe(s) + 3O_2(g) + 2xH_2O(l) = 2Fe_2O_3.xH_2O(s)$$

Other simpler equations would be

$$2Fe(s) + O_2(g) = 2FeO(s) \text{ and } 4Fe(s) + 3O_2(g) = 2Fe_2O_3(s)$$

c. The solid reductant added to the blast furnace with haematite is coke (carbon , C)

d. The oxygen from the air reacts with the coke to produce the gaseous reductant, carbon monoxide, according to the equation: $2C(s) + O_2(g) = 2CO(g)$.

e. Limestone or calcium carbonate is added to the blast furnace to help to remove some of the impurities from the molten iron. (The major impurity that remains is carbon at approximately 4%).The heat of the blast furnace causes the calcium carbonate to decompose according to the equation $CaCO_3(s) = CaO(s) + CO_2(g)$ and then $CaO(s) + SiO_2(s)$ (impurity from the ore) $= CaSiO_3(l)$.

Calcium oxide also reacts with aluminium and manganese oxides. This 'slag' floats on top of the molten iron at the base of the blast furnace and is easily removed.

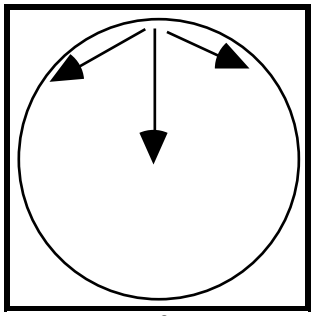
f. $2Fe(s) + 6HCl(aq) = 2FeCl_3(aq) + 3H_2(g)$

SUGGESTED SOLUTIONS **SECTION B**

Question 4

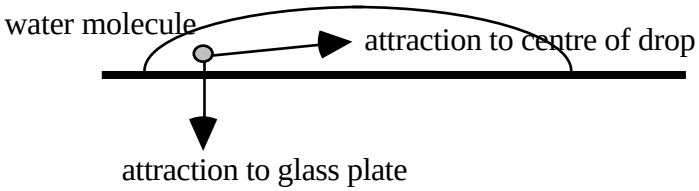
a. When water adopts a spherical shape, the surface energy is a minimum because a sphere has the smallest surface area for a given volume.

b. The forces acting on this water molecule are across the surface and towards the centre of the drop as shown below.

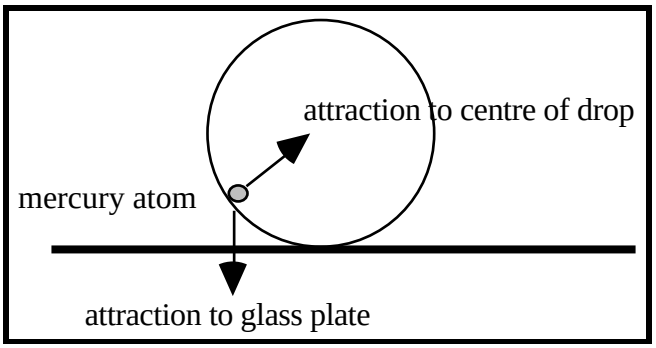


c. When a detergent is added to water, the surface energy of the water decreases and the water spreads out more over a surface thereby enabling the water to wet the surface more efficiently.

d.



e.



f. Surface tension is the force required to change a surface (measured in newtons per metre). Mercury (Hg) has a higher surface tension than water because the forces of attraction between the mercury ions and mobile electrons (metallic bonding) are greater than the hydrogen bonds between the water molecules. Hence, it is more difficult to stretch or deform the surface of mercury than the surface of water. This is shown by the fact that unlike water, mercury does not wet a glass surface.

SUGGESTED SOLUTIONS **SECTION B**

Question 5

a. $K_c = \dfrac{[H^+(aq)]_e\,[ClO^-(aq)]_e}{[HClO(aq)]_e}$ where 'e' indicates that the concentration is measured at equilibrium.

b. $n(HClO) = c \times V = 5.0 \times 10^{-8} \times 0.1 = 5.0 \times 10^{-9}$ mol L^{-1}. **ANS**

c. pH = 6.7 Therefore, $[H^+] = 10^{-6.7}$ mol L^{-1}. **ANS**

d. $[ClO^-] = \dfrac{K_c \times [HClO]}{[H^+]} = \dfrac{5.0 \times 10^{-8} \times 5.0 \times 10^{-8}}{10^{-6.7}} = 1.2 \times 10^{-8}$ mol L^{-1} **ANS**

e. If the pH is increased, the $[H^+]$ decreases. From the expression in **d.**, this would result in an increase in $[ClO^-]$.

SUGGESTED SOLUTIONS SECTION B

Question 6

a. Sulfur (S) can be used as a starting point for the manufacture of sulfuric acid.

b. $S(s) + O_2(g) = SO_2(g)$

c. Before further oxidation, the sulfur dioxide must be dried and purified to prevent the poisoning of the catalyst used in the next stage of production.
In the converter, sulfur dioxide reacts further with air to produce sulfur trioxide according to the equilibrium equation: $SO_2(g) + \frac{1}{2} O_2(g) \Leftrightarrow SO_3(g)$. This reaction is exothermic and produces a smaller number of mole of gas. Equilibrium principles would suggest that a higher yield of sulfuric acid would be produced in a given time by:

(1) using a low temperature (2) using high pressure (3) using an excess of air.
However, in practice low temperatures are not used since this would increase the time required to reach equilibrium. A compromise temperature of approximately 450 ^oC and a catalyst are used. High pressures are not used since the yield at atmospheric pressure is high and the extra yield does not justify the use of expensive pressure equipment. A moderate excess of air is used but not so much as to dilute the mixture excessively or increase pumping costs.

d. $SO_3(g) + H_2O(l) = H_2SO_4(aq)$

e. In the absorber the sulfur trioxide reacts with concentrated sulfuric acid to produce oleum which is diluted with water to produce 98% sulfuric acid. The equations for the reactions are: $SO_3(g) + H_2SO_4(l) = H_2S_2O_7(l)$ and $H_2S_2O_7(l) + H_2O(l) = 2H_2SO_4(l)$
Direct reaction of sulfur trioxide with water is not used since the reaction is highly exothermic and vaporises the sulfuric acid.

END OF SUGGESTED SOLUTIONS

1995 CHEMISTRY TRIAL CAT 1

CHEMISTRY ASSOCIATES
P.O. BOX 2227
KEW, VIC., 3101
AUSTRALIA
TEL:(03) 9817 5374 FAX: (03) 9817 4334