ALL SAINTS' COLLEGE

Semester One Examination, 2015

Question/Answer Booklet

Answers

CHEMISTRY
Stage 3A/B

Student Number: In figures | | | | | | | | |

In words _____

_____

Time allowed for this paper
Reading time before commencing work: ten minutes
Working time for paper: three hours

Materials required/recommended for this paper
To be provided by the supervisor
This Question/Answer Booklet
Multiple-choice Answer Sheet

To be provided by the candidate
Standard Items: pens (blue/black preferred), pencils (including coloured), sharpener, correction fluid/tap, eraser, ruler, highlighters

Special Items: non-programmable calculators approved for use in the WACE examinations

Important note to candidates
No other items may be taken into the examination room. It is **your** responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room. If you have any unauthorised material with you, hand it to the supervisor **before** reading any further.

Structure of this paper

Section	No. of Questions Set	No. of Questions to be Attempted	Marks Allocated	Recommended Time (approx) in Minutes
Section1: Multiple-choice	25	25	25 (25%)	50
Section 2: Short answers	9	9	35 (35%)	60
Section 3: Extended answer	4	4	40 (40%)	70

Total Marks for Paper = 100 (100%)

Instructions to candidates

1. The rules for the conduct of Western Australian external examinations are detailed in the *Year 12 Information Handbook 2015*. Sitting this examination implies that you agree to abide by these rules.

2. Answer the questions according to the following instructions.

   Section One - Answer on the separate Multiple-choice Answer Sheet.

   Section Two - Answer in this Question/Answer Booklet. Write your answers in the spaces provided, using a blue or black ballpoint or ink pen. Draw any diagrams in pencil. Additional working space and a spare graph is available at the end of this booklet.

   Section Three - Answer in the lined pages provided in the rear of this booklet

   Make sure your School Curriculum and Standards Authority Student Number is on your Multiple Choice Answer Sheet and this Question/Answer Booklet.

3. You must be careful to confine your responses to the specific questions asked and to follow any instructions that are specific to a particular question.

4. Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

   - Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.

   - Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

See next page

Chemical Equations

For full marks, chemical equations should refer only to those species consumed in the reaction and the new species produced. These species may be **ions** [for example $Ag^+(aq)$], **molecules** [for example $NH_3(g)$, $NH_3(aq)$, $CH_3COOH(aq)$] or **solids** [for example $BaSO_4(s)$, $Cu(s)$, $Na_2CO_3(s)$]. Phases MUST be shown in the equations for the first question of the short answer section.

Section One: Multiple-choice **25% (25 Marks)**

This section has **25** questions. Answer **all** questions on the separate Multiple-choice Answer Sheet provided. For each question place a cross in the box to indicate your answer. Use only a blue or black pen to cross the boxes. If you make a mistake, circle the incorrect answer and place a cross in a new box.

Suggested working time: 50 minutes.

Questions that many students got wrong: 11, 14, 17
Questions that some students got wrong: 2, 5, 6, 15, 18, 21

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1. What is the formula of an ionic compound consisting of positive ions with an electron configuration 2, 8, 8 and negative ions with the same configuration?

   A. KCℓ
   B. MgS
   C. NaF
   D. LiF

2. Which of the following elemental properties do not have an increasing trend from left to right across Period 3 of the Periodic Table?

   I. Atomic number
   II. Atomic size
   III. Electronegativity
   IV. Ionization energy
   V. Melting point

   A. III and IV
   B. I, III and IV
   C. II and V
   D. I, II, IV and V

3. Which type of bonding is not present in solid hydrogen chloride?

   A. covalent
   B. dipole – dipole
   C. dispersion force
   D. hydrogen bonding

See next page

4. Why is the bond between a sulfur atom and an oxygen atom polar?

A. The S atom has a higher positive charge in the nucleus than the O atom.
B. The O atom is more electronegative than the S atom.
C. The S atom is larger than the O atom.
D. The S atom has more electrons than the O atom, so it will be negative relative to the O atom.

5. Which of the following correctly describes the shape and polarity of the molecule given?

	Molecule	**Shape**	**Polarity**
A.	PBr_3	trigonal planar	polar
B.	CH_2F_2	tetrahedral	polar
C.	PBr_3	pyramidal	non-polar
D.	CH_2F_2	tetrahedral	non-polar

6. Which of the following lists contains atoms or molecules that have only dispersion forces as their most significant type of intermolecular force?

A. CH_4, N_2, SO_2, CO_2
B. CO_2, F_2, CO, CH_4
C. O_2, CS_2, CBr_4, He
D. Ne, H_2O, CS_2, CBr_4

7. The boiling points of a family of trihalomethanes (CHX_3) are listed below.

Tetrafluoromethane	CHF_3	–89 °C
Tetrachloromethane	$CHCl_3$	61 °C
Tetrabromomethane	$CHBr_3$	150 °C
Tetraiodomethane	CHI_3	330 °C

The increase in boiling points moving down the list is due to an increase in the strength of:

A. covalent bonding.
B. dispersion forces.
C. dipole-dipole bonding.
D. hydrogen bonding.

See next page

8. Which of the following statements concerning intermolecular forces is/are correct?

I Dispersion forces exist in all molecular solids.
II All molecules that contain polar bonds are polar molecules.
III Hydrogen bonding only occurs for molecules containing O-H bonds.

A. I only
B. II only
C. III only
D. I and II only

9. Which of the following statements regarding electronegativity are **true**?

(i) Electronegativity increases across the periods
(ii) Electronegativity increases down the groups
(iii) Fluorine is the most electronegative element
(iv) Electronegativity is a measure of an atom's power to attract an electron
(v) Group 18 elements are the most electronegative elements

A. (i) and (v) only
B. (i), (ii) and (v) only
C. (i) and (iv) only
D. (i), (iii) and (iv) only

► Questions 10 and 11 refer to the ionisation energy information in the table below:

Atom	Ionisation energy (kJ mol^{-1})				
	First	Second	Third	Fourth	Fifth
W	738	1451	7733	10543	13630
X	786	1577	3228	4352	16100
Y	419	3052	4420	5877	7975
Z	590	1145	4912	6491	8153

10. Which atom is most likely to be an alkali metal?

A. W
B. X
C. Y
D. Z

11. If the atoms in the table above were to each react with chlorine, which of the following compounds is least likely to form?

A. WCl_3
B. ZCl_2
C. XCl_4
D. YCl

See next page

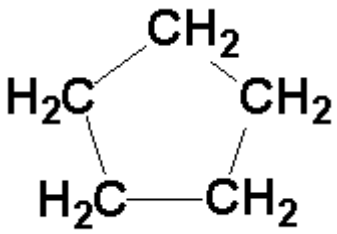
12. This question refers to the following chemical species:

I : CCl_4
II : $CH_3CH_2CH_2CH_2OH$
III: NaCl
IV: CH_3CH_2COOH

The correct sequence for increasing solubility in petrol (a mixture of octane and heptane) is:

A. I, II, IV and III.
B. III, IV, II and I.
C. III, II, IV and I.
D. IV, II, III and I.

13. The structural formula for cyclopentane is given below.



Which of the following compounds is an isomer of cyclopentane?

A. 2 - methylbutane.
B. 2 - pentene.
C. 2 - pentane
D. 2,3 - dimethylpropane.

14. Three organic liquids, (I, II and III) were reacted with sodium, bromine water (bromine dissolved in H_2O) and acidified potassium dichromate. The results are listed in the table below.

Liquid	Sodium	Bromine water ($Br_{2(l)}$)	Potassium dichromate
I	no reaction	no reaction	decolourised
II	gas evolved	no reaction	decolourised
III	gas evolved	decolourised	no reaction

Which of the following compounds could be liquid III?

A.

B. $CH_2=CH-\overset{\overset{O}{\|}}{C}-OH$

C. $CH_3CH_2\overset{\overset{O}{\|}}{C}H$

D. $CH_3CH_2CH_2OH$

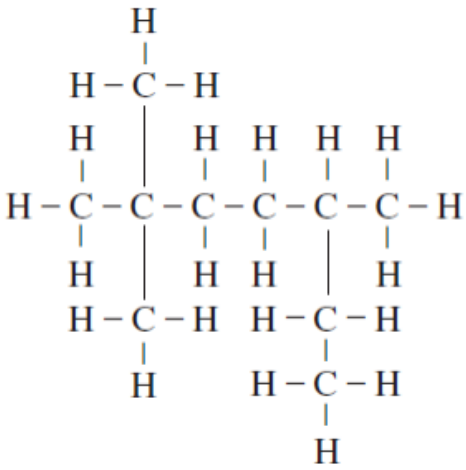
15. Synthetic detergents are more soluble than soap and are more effective in hard water.

Which one of the following compounds is an example of a synthetic detergent?

A. $CH_3(CH_2)_{10}CH_2OSO_3^-\ Na^+$.
B. $C_3(CH_2)_{10}COO^-\ Na^+$.
C. $CH_3(CH_2)_{12}CH_2O^-\ Na^+$.
D. $CH_3(CH_2)_{12}COOH$.

See next page

16. The IUPAC name for the structure below is:



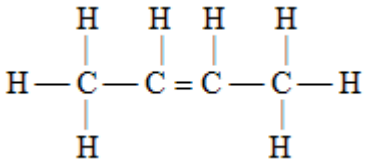
A. 2,2,5-trimethylheptane

B. 3,6,6-trimethylheptane

C. 2-ethyl-5,5-dimethylhexane

D. 5-ethyl-2,2-dimethylhexane

17. Which of the following statements are true about the compound represented by the formula below?



I it decolourises bromine water.

II it is soluble in water.

III it undergoes addition reactions with hydrogen chloride to form two different isomers with the formula C_4H_9Cl.

IV its systematic name is trans-2-butene.

A. I only.

B. I and III only.

C. I, III and IV only.

D. I, II, III and IV.

See next page

Questions 18 and 19 refer to the following information:

Sulfur trioxide gas is produced industrially in a reversible reaction involving sulfur dioxide gas and oxygen gas according to the equation:

$$2SO_2\,(g) + O_2\,(g) \Leftrightarrow 2SO_3\,(g)$$

The reaction to produce sulfur trioxide gas is exothermic.

The equilibrium constant for the reaction as written below at 600°C is 0.471.

$$2SO_3\,(g) \Leftrightarrow 2SO_2\,(g) + O_2\,(g)$$

18. If the temperature of the equilibrium mixture is decreased to 500°C, the value of the equilibrium constant for the reaction will be

A. less than 0.471.
B. equal to 0.471.
C. greater than 0.471.
D. unable to be determined from the information provided.

19. The equilibrium yield of sulfur trioxide could be increased by

A. increasing the temperature of the equilibrium mixture.
B. using a suitable catalyst.
C. increasing the pressure of the equilibrium mixture.
D. using less oxygen in the equilibrium mixture.

20. This reversible reaction has reached equilibrium.

$$Co^{2+}(aq) + 6NH_3(aq) \Leftrightarrow [Co(NH_3)_6]^{2+}(aq)$$

A small sample of $CoCl_2(s)$ was then added. As it dissolved the concentration of $Co^{2+}(aq)$ initially increased. When equilibrium is again established, how will the concentration of all species compare to their concentration prior to addition of $CoCl_2(s)$?

	$Co^{2+}(aq)$	$NH_3(aq)$	$[Co(NH_3)_6]^{2+}(aq)$
A.	same	lower	higher
B.	higher	lower	higher
C.	higher	higher	lower
D.	lower	lower	higher

See next page

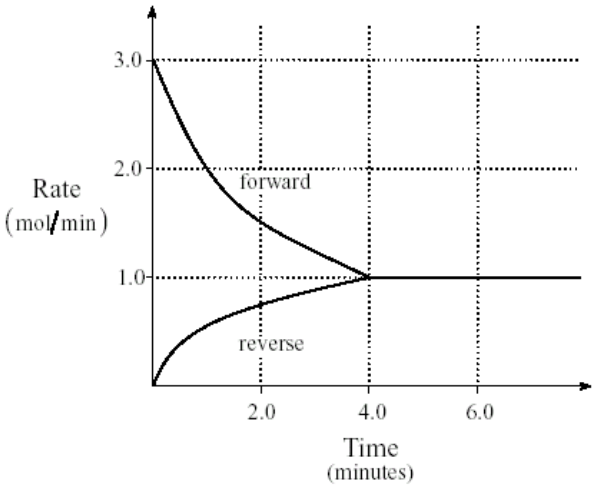
21. Nitrogen dioxide, NO_2, (brown) exists in equilibrium with dinitrogen tetroxide, N_2O_4 , (colourless) in a transparent container whose volume can be adjusted by means of a movable piston. The equation is:

$$\underset{\text{brown}}{2NO_2} \quad \Leftrightarrow \quad \underset{\text{colourless}}{N_2O_4}$$

An equilibrium mixture of NO_2 and N_2O_4 is cooled in the container at a fixed volume. As it cools, the brown colour becomes fainter. The equilibrium constant has

A. increased indicating that the reaction is exothermic.
B. decreased indicating that the reaction is exothermic.
C. increased indicating that the reaction is endothermic.
D. decreased indicating that the reaction is endothermic.

22. Consider the following graph:



When equilibrium is reached, the rate of the forward reaction is

A. 0.00 mol/min
B. 0.25mol/min
C. 1.0 mol/min
D. 3.0 mol/min

23. Ethene, C_2H_4, can be produced in the following industrial system:

$$C_2H_{6\,(g)} + \text{energy} \rightleftharpoons C_2H_{4\,(g)} + H_{2\,(g)}$$

The conditions that are necessary to maximize the equilibrium yield of C_2H_4 are

A. low temperature and low pressure.
B. low temperature and high pressure.
C. high temperature and low pressure.
D. high temperature and high pressure.

See next page

The next two items refer to the following information.

Some of the properties of the pure substances *W, X, Y* and *Z* are given below.

Substance	Hardness Of solid	Melting Point (º C)	Electrical conductivity of solid	Electrical conductivity of solution
W	Soft	-120	Negligible	High
X	Soft	20	Negligible	Negligible
Y	Hard	800	Negligible	High
Z	Hard	2850	Negligible	Not measured (insoluble)

24. The substance most likely to be a covalent network substance is

A. *W*
B. *X*
C. *Y*
D. *Z*

25. The substance most likely to be an ionic network substance is

A. *W*
B. *X*
C. *Y*
D. *Z*

END OF SECTION ONE

See next page

Section Two: Short answer **35% (35 Marks)**

This section has **nine (9)** questions. Answer **ALL** questions. Write your answers in the spaces provided.

Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

- Planning: If you use the spare page for planning, indicate this clearly at the top of the page.
- Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question that you are continuing to answer at the top of the page.

Suggested working time: 60 minutes.

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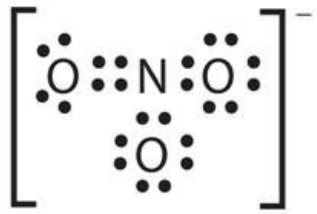
1. Draw an electron-dot diagram of the following and state its geometry according to the VSEPR theory:

(a) Nitrate ion (NO_3^-)	(b) Sulphur Dibromide (SBr_2)
 Shape: Triangular Planar	 Shape: V-shaped (bent)

1 mark for correct electron dot diagram (deduct half mark for any mistakes)
0.5 mark for correct shape

(3 marks)

2. Explain in a paragraph why an element (Element "A") with electron structure 2, 8, 2 would have a larger atomic radius than another element (Element "B") whose electron structure is 2, 8, 5.

Element B has a higher core charge than element A (1)
(or reference to increasing number of protons, same shielding effect)
Statement needs to refer to core charge, do not accept higher number of Protons or higher atomic number

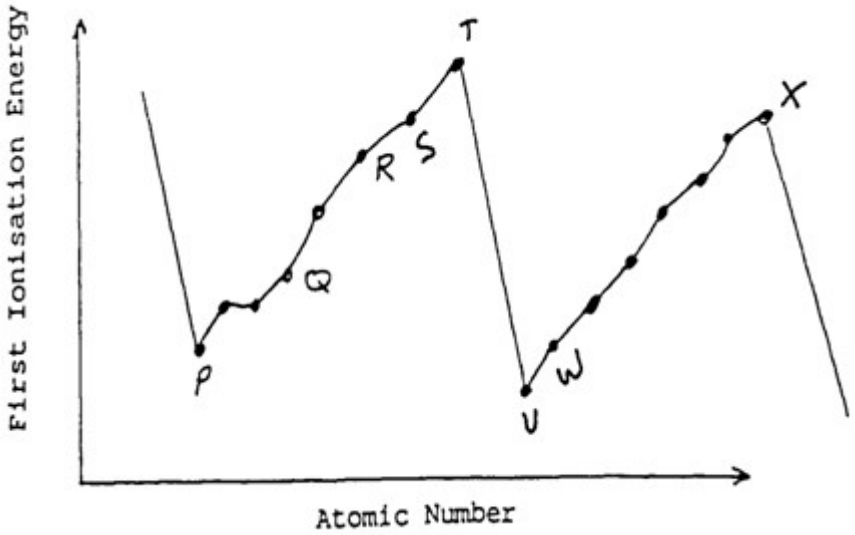
The valence electron in element B is therefore pulled more strongly and closer to the nucleus than in element A (1)

Both elements are in the same period, therefore have the same number of energy levels, and this will therefore not have an influence on atomic radius (1)

(3 marks)

See next page

3. This question refers to the following graph that shows the first ionisation energies of a number of elements P, Q, R, S, T, V, W and X.



(a) Which pairs of labeled elements are likely to form an ionic compound with each other?

Any combination of
P, U, W with R or S

(1 mark)

(b) The compound ST_6 has just been made at a research institute in the United States. The conditions for its production were <u>extreme</u> to say the least. Comment on the reasons for the difficulties faced in its production.

Identifies T as a noble gas **(1)**

T fairly unreactive due to stable electron configuration
Award second mark only if reference to electron config is made **(1)**

(2 marks)

See next page

Another possible compound that may be formed is S_2R.

(c) Give **one** likely physical property of this compound.

Any one of: Low MPt, soft, non-conductor of electricity

(1 mark)

(d) Which element would be the easiest to oxidise?

V

(1 mark)

(e) Why is there a rise in the first ionization energy as you go from element P → T on the periodic table?

The core charge (or effective nuclear charge) increases from element P to T (1)

Valence electrons are therefore pulled to the nucleus more strongly (1)

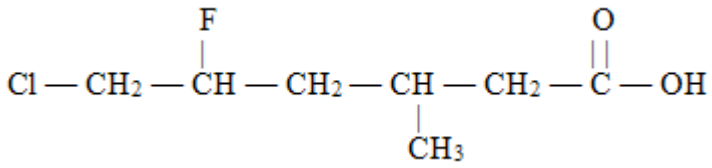
More energy is required to remove the electron against this attraction (1)

Do not accept 'increasing atomic number' or 'increasing number of protons' without any reference to constant shielding

(3 marks)

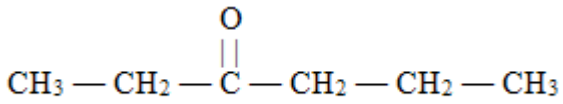
4. Give the correct I.U.P.A.C. name for the following organic molecules:

(a)



6-chloro-5-fluoro-3-methylhexanoic acid

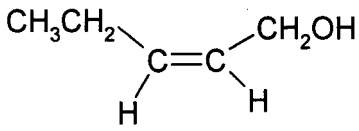
(b)



3-hexanone or hexan-3-one

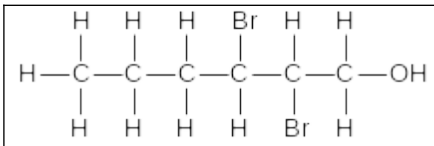
(2 marks)

5. The compound below (X) contributes to the 'leafy' odour of violet oil.



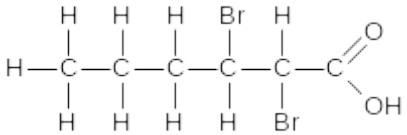
A Chemist reacted compound X with Br_2 and produced compound Y.
The Chemist then reacted Y with excess acidified potassium permanganate solution to form compound Z.

(a) **Draw the full structural diagram** of compound 'Y' making sure to show all hydrogen atoms and give the correct I.U.P.A.C. **name of the compound**.



Name:**2,3-dibromopentan-1-ol**

(b) **Draw the full structural diagram** of compound 'Z' making sure to show all hydrogen atoms and give the correct I.U.P.A.C. **name of the compound**.



Name: **2,3-dibromopentanoic acid**

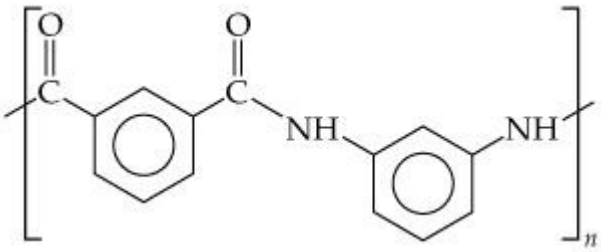
For this question, follow-through marks are awarded if an incorrect structure is named correctly.

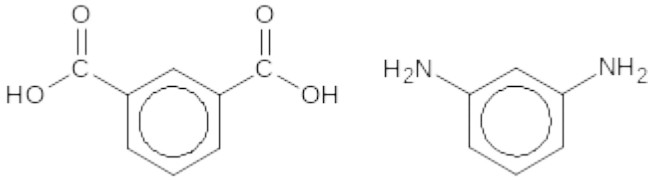
See next page

(4 marks)

6. For each of the polymer structures shown **draw the monomer or monomers** used in its manufacture and state the polymerization type:

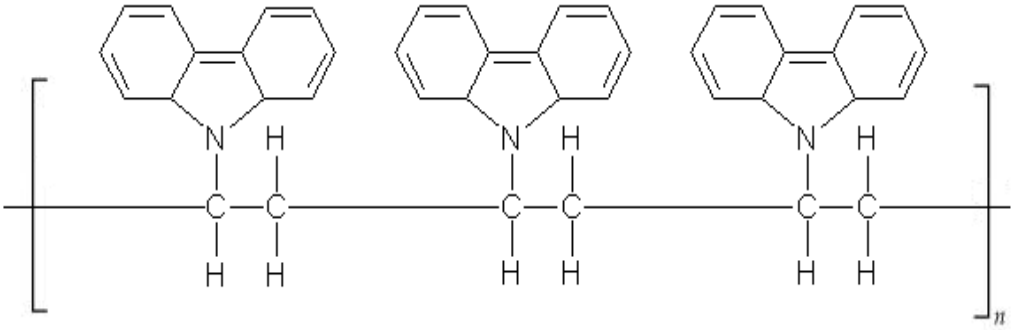
(a)

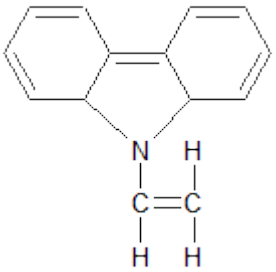




Polymerisation Type: **Condensation polymerisation**

(b)



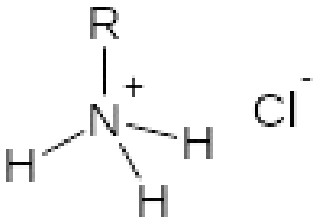


Polymerisation Type: **Addition polymerisation**

(4 marks)

See next page

7. Quaternary ammonium salts can be represented by the following structural formula.



If the alkyl group (R) is long then the salt acts like a soap or detergent. If it is short the salt has no cleaning properties.

Explain these two differences in properties. Include a labelled diagram.

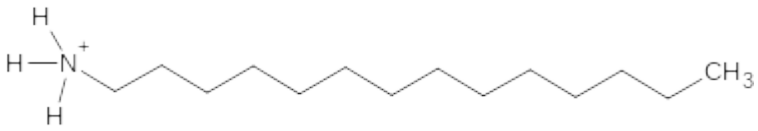
The cleaning property of a soap depend on the interaction of the polar head with water molecules (ion-dipole) (1)

And the interaction of the long alkyl chain with grease (dispersion) (1)

If the alkyl chain is short, the dispersion forces are weak (1)

With a short alkyl chain, grease is not broken up and enclosed (1)

Diagram needs to show interaction between soap molecule and grease and water, needs to be labelled with the following words: hydrophobic tail, hydrophilic head. (1)



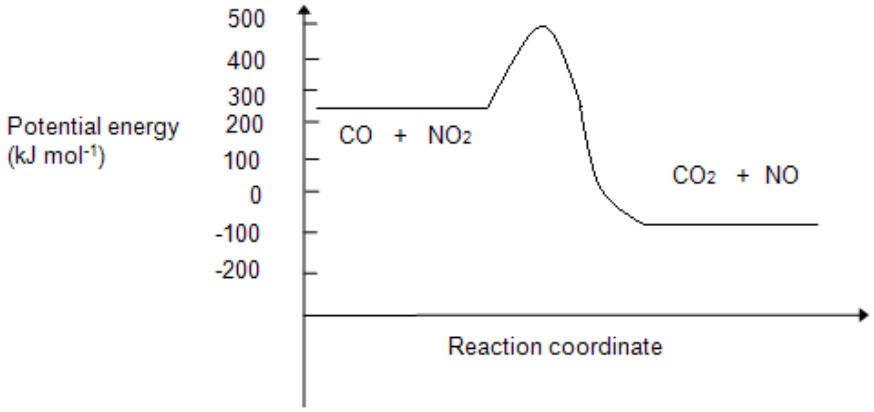
Hydrophillic head hydrophobic tail

(5 marks)

See next page

8. The reaction profile diagram below is for the equilibrium reaction of carbon monoxide with nitrogen dioxide to produce carbon dioxide and nitric oxide:

$$CO_{(g)} + NO_{2(g)} \Leftrightarrow CO_{2(g)} + NO_{(g)}$$



(a) What is the value of the activation energy (in kJ.mol^{-1}) for the reverse reaction?

+ 600 kJ (any value above 580 kJ)

(b) Is the forward reaction as written exothermic or endothermic?

Exothermic

(c) What change would occur to the shape of this curve if a suitable catalyst was added?

The maximum of the curve (activated complex, transition state) would be lowered.

(d) What is the equilibrium law expression (K) for this equilibrium?

$$K = \frac{[CO_2]\,[NO]}{[CO]\,[NO_2]}$$

Mark not awarded if 'K=' is missing

(e) Is it **true** or **false** to say that there will be no change in equilibrium position if the volume of the container is changed?

True

(f) Is it **true** or **false** to say that there will be no change in the concentration of any of the gases in this equilibrium if volume of the container is changed?

False

(3 marks)

See next page

9. Consider the following reaction:

$$NaNO_{3(s)} \Leftrightarrow Na^{+}_{(aq)} + NO_{3}^{-}{}_{(aq)}$$

Given that the reaction is endothermic:

(a) What shift in **equilibrium position** would Le Chatalier's principle predict if the saturated sodium nitrate solution above is heated.

Shift to the right **(1)**

(c) Explain in terms of **reaction rates** why this shift occurs.

As temperature increases, there will be more collisions between reactant particles as more particles have sufficient energy to overcome activation energy; therefore both rates will increase **(1)**

The forward rate will be increased more than the reverse rate, as it is endothermic and an increase in temperature will mean that the endothermic reaction is favoured to oppose the change and use up the heat. **(1)**

(3 marks)

END OF SECTION TWO

Section Three: Extended answer **40% (40 Marks)**

This section contains **four (4)** questions. You must answer **ALL** questions. Write your answers in the answer book provided.

Any calculations are to be set out ***in detail*** in the answer booklet provided. You may be penalized significantly for failure to show appropriate working, even if you obtain the correct numerical answer. Marks will be allocated for correct equations and clear setting out of a partial answer, even if you cannot complete the problem.
This part carries **40 marks**.

Numerical answers **MUST** be corrected to **THREE (3) SIGNIFICANT FIGURES**.

Suggested working time: 70 minutes.

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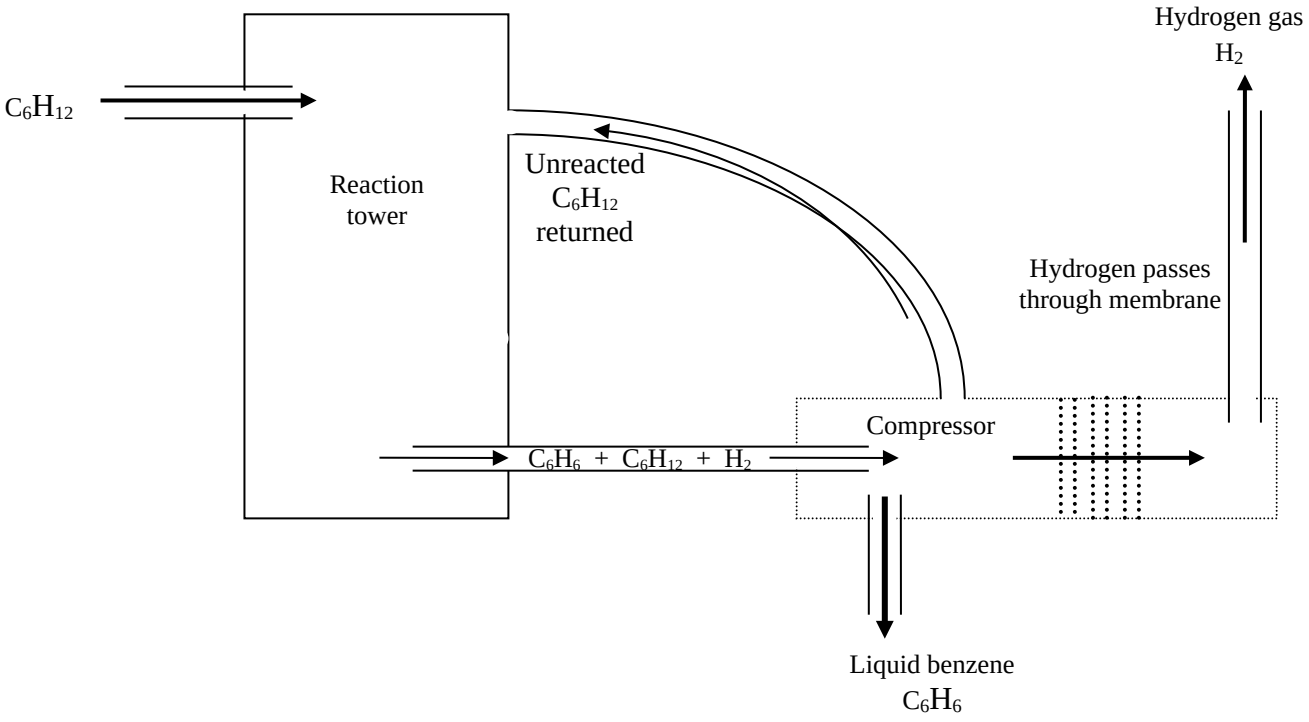
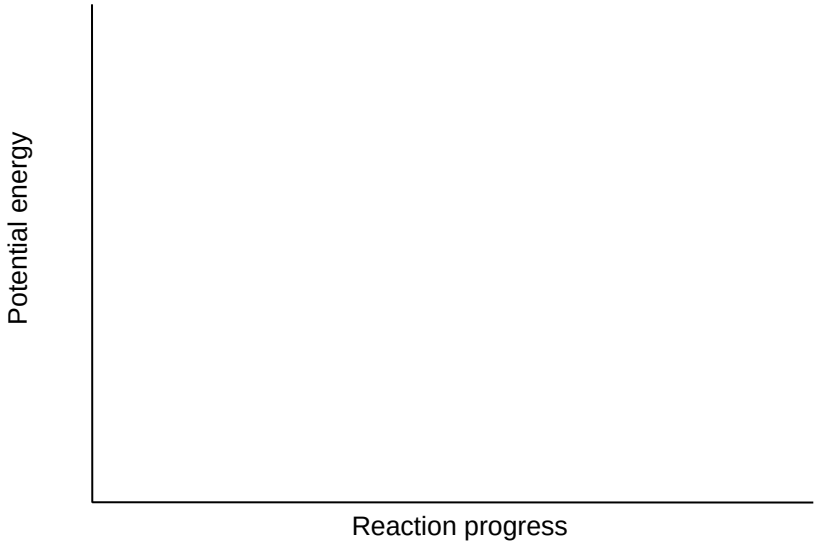
1. **Production of benzene** **14 marks**

Benzene (C_6H_6) can be produced by the dehydrogenation of cyclohexane (C_6H_{12}) gas. The reaction has a high activation energy (880 kJ mol−1), is also endothermic and reversible. The cyclohexane (C_6H_{12}) passes through a special reaction tower where hydrogen is chemically removed. The benzene/cyclohexane/hydrogen mixture then passes through a compressor, where the benzene is liquefied. A special membrane in the compressor allows the small hydrogen molecules to pass through, and out. The unreacted cyclohexane (C_6H_{12}) gas is then returned to the reaction tower.

$$C_6H_{12\,(g)} + 120\ kJ \rightleftharpoons C_6H_{6\,(g)} + 3\,H_{2\,(g)}$$



a) Draw a labelled energy profile diagram for the reaction.



(3 marks)

b) Write an equilibrium constant expression for the reaction.

$$K = \frac{[C_6H_6]\,[H_2]^3}{[C_6H_{12}]}$$ **(need to state "K =")**

(2 marks)

c) Under what conditions will the rate of the forward reaction be greatest?

High P and high T and catalyst

(3 marks)

d) For a mixture of all three gases at equilibrium in a sealed container, what conditions will produce the maximum yield of benzene?

Low P and high T (2 marks)

e) Suggest conditions that would be used for the commercial production of benzene using this process.

Explain, making reference to Le Chatelier's Principle and Collision Theory why you chose these conditions.

Explain high temp favoured from a rate perspective.

Explain high temp favoured from a yield perspective

Explain high pressure favoured from rate perspective

Explain low pressure favoured from a yield perspective

Compromise conditions of high temp and moderate pressure

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Catalyst – needs to explain the effect on rate.

(4 marks)

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2. **6 Marks**

280.0 mL of hydrogen sulifde gas (H_2S) gas at 25°C and at 96.0 kPa were bubbled into 155 mL of a 0.206 mol.L^{-1} lead (II) nitrate solution producing lead (II) sulfide precipitate according to the following equation:

$$Pb^{2+}_{(aq)} + S^{2-}_{(aq)} \rightarrow PbS_{(s)}$$

Calculate the:

a) Determine the limiting reactant. (Your working must clearly show how you have determine the limiting reactant).

b) Mass of any precipitate formed.

c) Individual concentrations (in mol.L^{-1}) of any ions remaining in the final solution.

** Note: The addition of gas does not impact on the solution volume*.

(6 marks)

a)

$n(Pb(NO_3)_2)$ = c V = 0.206 mol/l x 0.155 l

= 0.03193 mol = $n(Pb^{2+})$ **(0.5)**

$n(H_2S)$ = p x V /R x T = 96 kPa x 0.280 L /8.314 x 298.15

= 0.01084 mol H_2S = mol (S^{2-}) **(0.5)**

Stoichiometric ratio: Pb/S = 1

Actual ratio: Pb/S = 0.03193 mol/0.01084 mol = 2.9456

S^{2-} is the limiting reagent **(1)**

b)

1 mol S^{2-} = 1mol PbS = 0.01084 mol

m(PbS) = 0.01084 mol x 239.27 g/mol

= 2.5936 g

= <u>2.59 g PbS (3 SF)</u> **(1)**

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c)

$n(Pb(NO_3)_2)$ left = $n(Pb(NO_3)_2)$ added at the beginning - $n(Pb(NO_3)_2)$ used

$n(Pb(NO_3)_2)$ left = 0.03193 mol – 0.01084 mol = 0.02109 mol

$n(Pb2+)$ = $n(Pb(NO_3)_2)$ = 0.02109 mol

V(total) = 155 mL

$c(Pb2+)$ = 0.02109 mol/0.155 L = <u>0.136 mol/L (3SF)</u> **(1)**

$n(H^+)$ left = nH_2S added x 2

0.01084 x 2 = 0.02168 mol

cH^+ = n/V(total) = 0.02168 mol/0.155 L = <u>0.140 mol/L (3SF)</u> **(1)**

$n(NO_3^{-1})$ = 2 x $n(Pb^{2+})$ = 0.06386 mol

$c(NO_3^{-1})$ = n/V = 0.06386/0.155 = 0.412 mol/L **(1)**

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3. **10 Marks**

An Organic compound is known to contain the elements carbon, hydrogen, nitrogen and oxygen. Combustion of a 6.926g sample of this compound yields 11.82g of carbon dioxide and 5.437g of water, the mixture of nitrogen oxides was not analysed. Another 6.926g sample of the compound was found to contain a percentage mass of Nitrogen of 13.6%

a) Calculate the mass of nitrogen in the 6.926g sample.

$m(N) = 6.926\ g \times 13.6/100 = 0.9419\ g$ **(1)**

b) Calculate the empirical formula of the compound.

$C_xH_yO_zN_w$ + O_2 --> CO_2 + H_2O

6.926 g 11.82 g 5.437 g

$n(CO_2) = 11.82/44.01 = 0.2686\ mol = n(C)$
$m(C) = 0.2686\ mol \times 12.01\ g/mol = 3.226\ g$ **(1)**

$n(H_2O) = 5.437/18.016 = 0.3018\ mol$
$n(H) = 2 \times n(H_2O) = 0.6036\ mol$ **(1)**
$m(H) = 0.6036\ mol \times 1.008\ g/mol = 0.6084\ g$ **(1)**

m(O) = m(total) – m(C+H+N)
= 6.926 g – (3.226 + 0.6084 + 0.9419) = 2.1497 g
n(O) = 2.1497/16 = 0.1344 mol **(1)**

n(N) = 0.9419/14.01 = 0.0672 mol **(1)**

	C	H	O	N
Moles	**0.2686**	**0.6036**	**0.1344**	**0.0672**
Ratio	**3.997**	**8.98**	**1.99**	**1**

$C_4H_9O_2N$ **(1)**

c) Given that the molecular weight is 103.112 g.mol-1 determine the molecular formula.

EFM ($C_4H_9O_2N$) = 103.122 g/mol

EFM = M ==> Molecular formula = Empirical formula **(1)**

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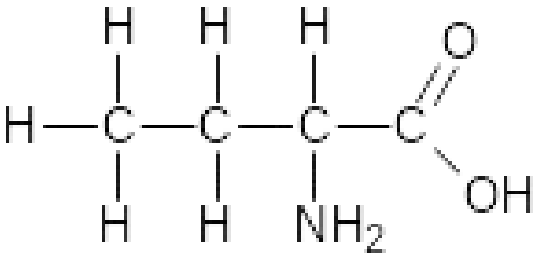
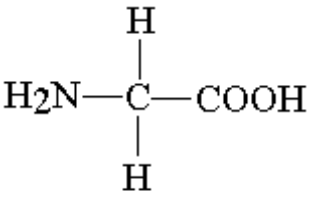
d) Given that the molecule is an alpha-amino acid, give a possible molecular structure. **(1)**



e) The material produced was found to polymerise with the amino acid glycine, which has the formula shown below. Show two repeating units of the protein that is formed. **(1)**



glycine

(10 marks)

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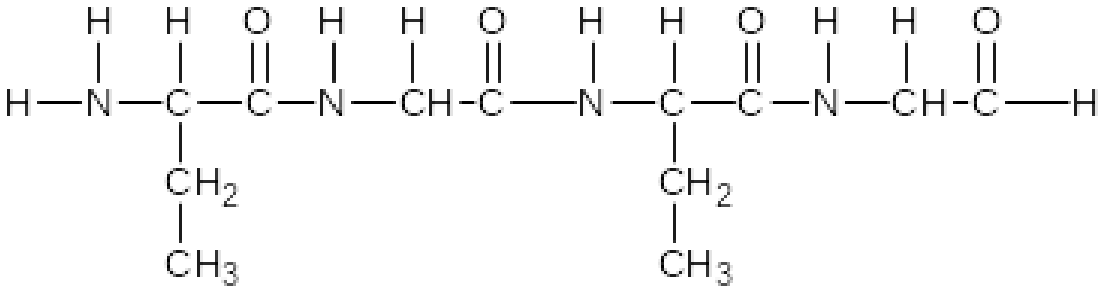

4.

10 marks

Water and kerosene (a mixture of alkanes with 12 to 16 carbon atoms) are two vastly different substances, although they visually appear quite similar. Both are clear, colourless liquids (although Kerosene is often tinted blue as a safety measure), and both are effective solvents in their own right. Given your knowledge of intermolecular forces, solubility, the water molecule and the structure of alkanes answer the questions below.

NB – It is not enough to just give an observation, you need to provide an explanation as well.

a) Detail the attractive forces between the water molecules.

Identifies H-bonding between water molecules (0.5)

Describes the creation of strong dipoles due to electronegativity difference between Hand O. (0.5)

Describes the sites for H-bonding: attraction between the H bonded to oxygen and a lone pair on the oxygen of another water molecule (1)

(2 marks)

b) Detail the attractive forces between kerosene molecules.

Identifies dispersion forces between kerosene molecules (0.5)

Makes reference to strength of dispersion force: relatively large molecule (between 12 and 16 C-atoms, therefore a lot of electron, therefore strong dispersion forces - may mention straight chain results in larger forces (1.5)

(2 marks)

c) What is the solubility of water in kerosene? – explain.

States the solubility: Low/will not dissolve (0.5)

Discusses Solvent-solvent, solute-solute and solute-solvent interaction. Resistance to mixing outweighs any assistance to mixing.

(1.5)

See next page

(2 marks)

d) Would ionic solutes, such as NaCl dissolve in water? - explain.

States solubility: Yes (0.5)

Electrostatic attraction in NaCl needs to be overcome. Ion-dipole interaction occurs between ions in the salt and H_2O. This assistance to mixing allows the salt to dissolve.

(1.5)

(2 marks)

e) Would ionic solutes such as NaCl dissolve in kerosene? – explain.

States solubility: No (1)

Kerosene only exhibits dispersion forces. As there are no dipoles, there is no-ion dipole interaction present to overcome the electrostatic attraction of ions in the solid salt.

(1.5)

(2 marks)

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Additional Working Space

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END OF PAPER

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