CHEMOLOGY EDUCATION SERVICES

Name:________________________

2014 CHEMISTRY Unit 3 & 4
TRIAL EXAM

Time allowed: 2 hours 30 minutes

QUESTION AND ANSWER BOOKLET

Structure of booklet

Section	Number of questions	Number of questions to be answered
A	30 multiple choice questions	30
B	13	13

Directions to students

Materials
Question and answer booklet of 31 pages.
Answer sheet for multiple choice questions.
An approved calculator may be used.
Data Booklet

The Task
Pleasure ensure that you write your name on the multiple choice answer sheet and this answer booklet.
Answer **all** items from Section A, which should be answered on the sheet provided.
Answer **all** questions from Section B, which should be answered in this booklet in the spaces provided.
There is a total of 10 marks available.
All answers should be written in English.

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SECTION A

Specific instructions for Section A

Question 1 consists of 30 multiple choice questions. Section A is worth approximately 22% of the marks available.

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

No credit will be given for an item if two or more letters are marked for that question. Marks will not be deducted for incorrect answers and you should attempt every question.

Question 1

What is the mass of NaOH required to prepare 100.0mL of NaOH((aq)) that has a pH =13.62 ?

A. 0.38g
B. 0.42g
C. 1.67g
D. 2.40 x 10^{-14} g

Question 2

Cellulose cannot be digested by humans because:

A. it is insoluble in water.
B. it contains no glucose.
C. it is not a carbohydrate.
D. the enzymes required to catalyse its hydrolysis are not present in humans.

Question 3

A pH 3.0 solution of HCl(aq) is diluted by adding water to produce a pH 5.0 solution. Which row in the following table correctly identifies an appropriate volume of the original solution and the volume of water added for this dilution?

	Volume of original solution (mL)	*Volume of water added* (mL)
(A)	100	900
(B)	100	1000
(C)	10	990
(D)	1	1000

Question 4
Sodium reacts with water to give hydrogen gas and sodium hydroxide solution.
What volume of gas would be produced from the reaction of 23.0 g of sodium at 25°C and 100 kPa?

A. 11.36 L
B. 12.38 L
C. 22.71 L
D. 24.79 L

Question 5
What is the purpose of the flame in atomic absorption spectroscopy (AAS)?

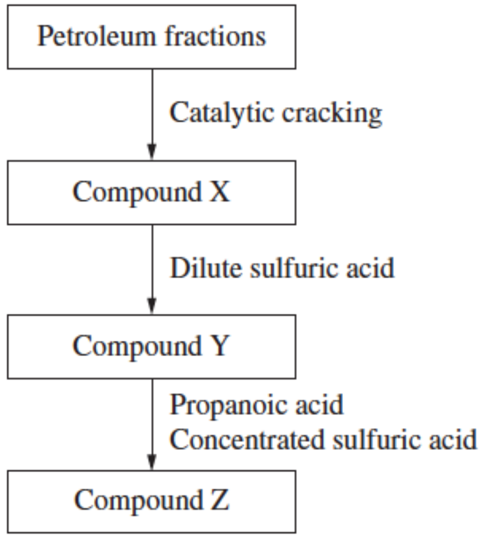
A. To ionise the sample
B. To produce a spectrum
C. To atomise the substance
D. To provide the absorption wavelength

Question 6
A 25.0 mL sample of a 0.100 M hydrochloric acid solution completely reacted with 23.4 mL of sodium hydroxide solution.
What volume of the same sodium hydroxide solution would be required to completely react with 25.0 mL of a 0.100 M acetic acid solution?

A. Less than 23.4 mL
B. 23.4 mL
C. More than 23.4 mL
D. Unable to calculate unless the concentration of the sodium hydroxide solution is also known

Question 7

Consider the following series of reactions.



Which row in the table correctly identifies Compounds X, Y and Z?

	Compound X	*Compound Y*	*Compound Z*
(A)	Propene	Propan-1-ol	Ethyl propanoate
(B)	Propene	Ethanol	Propyl ethanoate
(C)	Ethanol	Ethylene	Propyl ethanoate
(D)	Ethylene	Ethanol	Ethyl propanoate

Question 8

A sample of hydrocarbon contains 81.8% carbon by mass.
The empirical formula of the compound would be:

A. CH_4
B. CH_3
C. C_2H_5
D. C_3H_8

Question 9
In a particular solvent used for thin-layer chromatography (TLC), compounds A and B have R_f values, as shown in the table below.

Compound	R_f value
A	0.46
B	0.15

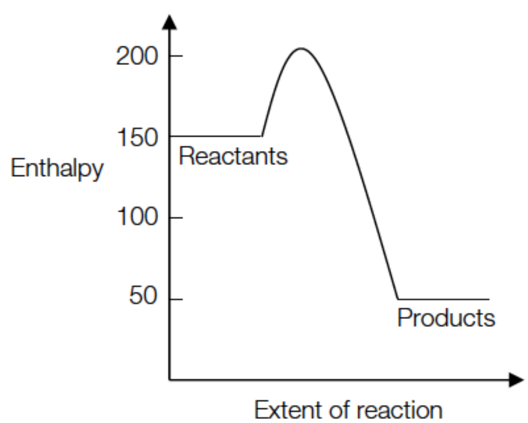
In one analysis, compound A travels 3.5 cm from the origin. The origin is marked at 0.7 cm from the bottom of the plate. The distance, in cm, travelled by compound B from the origin will be

A. 0.91
B. 1.14
C. 1.84
D. 4.2

Question 10
When Nuclear Magnetic resonance spectroscopy is used to identify an organic substance the

A. bonds that contain hydrogen atoms vibrate and stretch or bend in the induced magnetic field
B. bonds in the molecule will stretch and bend at characteristic frequencies
C. molecule will absorb radiation of a known wavelength, exciting electrons
D. hydrogen nuclei align themselves in the induced magnetic field.

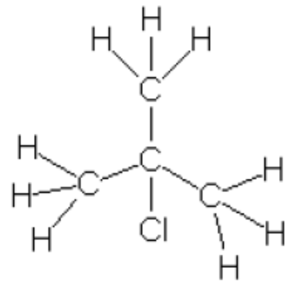
Question 11
Consider the following energy profile diagram for a particular reaction.



The numerical value of the activation energy for the reverse reaction is

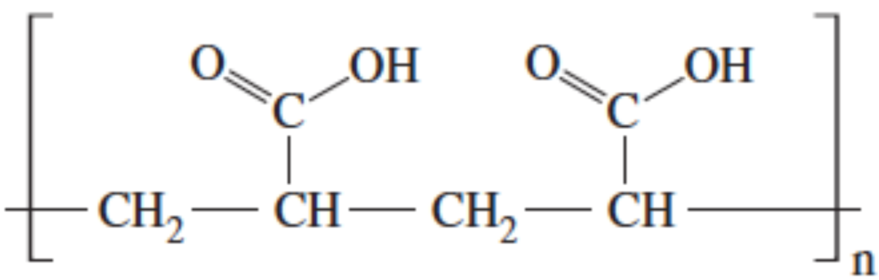
A. +150
B. +50
C. –150
D. –100

Question 12
What is the correct systematic name for the following compound?



A. 2-methyl-chloropropane
B. 2-methyl-chlorobutane
C. 2-chloro-2-methylpropane
D. 2-chloro-2-methylbutane

Question 13
A portion of a resin made from acrylic acid (CH_2 =CHCOOH) is shown.



Which type of reaction results in the formation of this polymer?

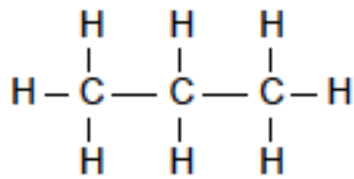
A. Addition
B. Condensation
C. Dehydration
D. Esterification

Question 14
Which one of the following compounds would have a strong absorbance in the infrared spectrum around 3400 cm^{-1}, but not in the 1700 cm^{-1} region?

A. Butanoic acid, $CH_3CH_2CH_2COOH$.
B. Diethyl ether, $CH_3CH_2OCH_2CH_3$.
C. Butan-1-ol, $CH_3CH_2CH_2CH_2OH$.
D. Ethyl ethanoate, $CH_3CH_2OOCCH_3$.

Question 15

A molecule of propane is drawn below.

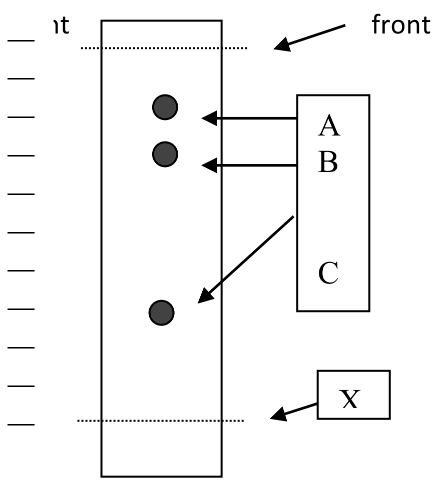


A proton NMR spectrum of propane will show

A. one singlet (single peak) because all protons have the same environment
B. two sets of peaks, one a quartet and the other a triplet
C. two sets of peaks, one a septet (seven) and the other a triplet
D. three sets of peaks because there are three different proton environments

Question 16

The diagram below shows a chromatogram obtained from Thin Layer Chromatography. The sample was originally placed at X.



Which one of the following is true?

A. Component A is most strongly adsorbed.
B. Component B has an R_f value of 0.70
C. Component C is the least strongly adsorbed.
D. Position X must be originally below the solvent.

Question 17
Which of the following statements about pure water is correct?

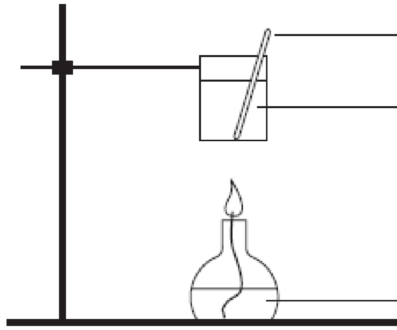
A. Kw is always 10^{-14}.
B. If the pH is not equal to 7, then the water cannot be pure.
C. If the $[H_3O^+]$ is $10^{-6.8}$ M, then $[OH^-]$ will be $10^{-6.8}$ M.
D. If the $[H_3O^+]$ is $10^{-6.8}$ M, then $[OH^-]$ will be $10^{-7.2}$ M.

Question 18
Which of the following are necessary for successful collisions between reactant molecules?

I.	high concentration
II.	sufficient energy
III.	correct geometry
IV.	presence of a catalyst

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

Question 19
A student used the apparatus below to determine the molar heat of combustion of propanol, C_3H_7OH.



The following results were obtained:

Mass of 1-propanol burnt	= 0.60 g
Mass of water heated	= 200 g
Initial temperature of water	= 21.0°C

The molar heat of combustion of 1-propanol is 2021 kJ mol^{-1} and it takes 4.18J to raise 1g of water by 1°C. Assuming no heat loss, what would be the final temperature of the water?

A. 24.2°C
B. 29.1°C
C. 45.2°C
D. 48.4°C

Question 20
The following equilibrium is set up in a sealed reaction vessel.

$$N_2O_4(g) \rightleftharpoons 2NO_2(g) \qquad \Delta H = +54.8 \text{ kJ mol}^{-1}$$

Which of the following would INCREASE the yield of nitrogen dioxide?

A. Adding a catalyst to the reaction vessel
B. Decreasing the volume of the reaction vessel
C. Raising the temperature of the reaction vessel
D. Increasing the pressure by adding argon to the reaction vessel

Question 21
The table shows the heat of combustion for four compounds.

Compound	*Heat of combustion* ($kJ\ mol^{-1}$)
CO	233
CH_4	890
C_2H_2	1300
C_2H_6	1560

Which of these compounds would produce the greatest amount of energy if 1.00 g of each is burnt?

A. CO
B. CH_4
C. C_2H_2
D. C_2H_6

Question 22
Some brown coloured nitrogen dioxide was allowed to reach equilibrium according to the reaction below

$$N_2O_4(g) \rightleftharpoons 2NO_2(g)$$

If the reaction mixture was contained in a vessel of variable volume and the volume was doubled, then which of the following is correct when equilibrium has be attained.

A. The value of the equilibrium constant would double.
B. The intensity of the brown colour would be less.
C. The reaction would move backward.
D. The concentration of NO_2 would be greater than before the volume was halved.

Question 23
Styrene is manufactured as follows:

$$C_6H_5CH_2CH_3\,(g) \rightarrow C_6H_5CHCH_2\,(g) + H_2\,(g) \quad \Delta H = -123 \text{ kJ mol}^{-1}$$

Which of the following describes the temperature and pressure needed for the maximum yield of styrene?

	Temperature	Pressure
A.	low	low
B.	low	high
C.	high	low
D.	high	high

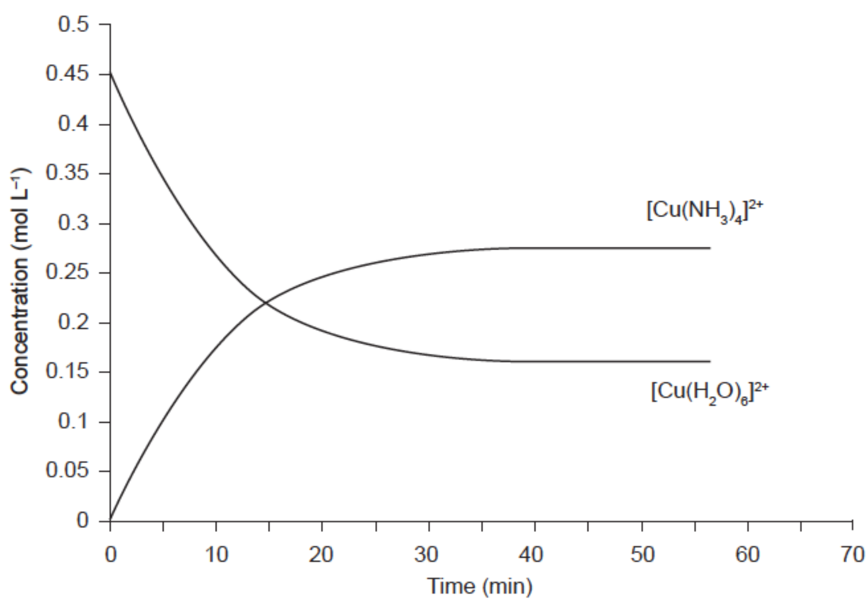
Questions 24 and 25 refer to the information and graph below.

Aqueous solutions of copper(II) ions and ammonia form the equilibrium represented below.

$$[Cu(H_2O)_6]^{2+}(aq) + 4\,NH_3(aq) \rightleftharpoons [Cu(NH_3)_4]^{2+}(aq) + 6\,H_2O(\ell)$$

pale blue — deep royal blue

The following graph shows the changes in concentration with time for $[Cu(H_2O)_6]^{2+}$ and $[Cu(NH_3)_4]^{2+}$ ions when solutions of copper(II) nitrate and ammonia are mixed.



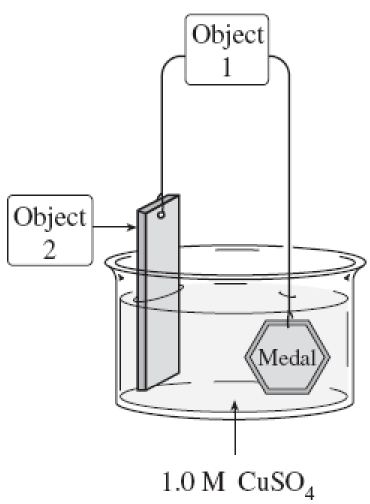
Question 24
Which one of the following statements is true for this equilibrium system?

A. The system reaches equilibrium at approximately 35 minutes.
B. At equilibrium, the concentration of NH_3 will always be four times greater than the concentration of $[Cu(NH_3)_4]^{2+}$.
C. Adding ammonia to the system will decrease the equilibrium constant.
D. At equilibrium, the rate of the forward reaction is less than the rate of the reverse reaction.

Question 25
Which one of the following would be observed if a small quantity of concentrated nitric acid was added to the system after it had reached equilibrium?

A. The solution would be a deeper royal blue colour.
B. The solution would be a paler blue colour.
C. There would be no change in the colour of the system.
D. Copper(II) nitrate crystals would precipitate from solution.

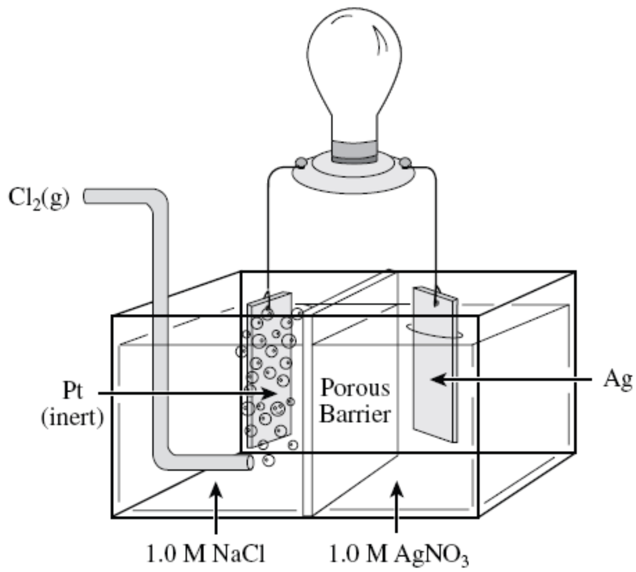
Question 26
A student brought an old silver medal to the chemistry lab to plate it with copper.
He set up a cell like the one in the following diagram using 200ml of 1.0M $CuSO_4$



A current of 10.72A is run passed through the cell for 15 minutes. The final concentration of the $CuSO_4$ solution is

A. 0.25M
B. 0.50M
C. 0.75M
D. 1.0M

Use the following diagram to answer questions 27 and 28.



Question 27
Which of the following gives the anode material and its correct half-reaction?

	Anode	Anode Half-reaction
A.	Pt	$2Cl^- \rightarrow Cl_2 + 2e^-$
B.	Cl_2	$Cl_2 + 2e^- \rightarrow 2Cl^-$
C.	Ag	$Ag \rightarrow Ag^+ + e^-$
D.	Ag	$Ag^+ + e^- \rightarrow Ag$

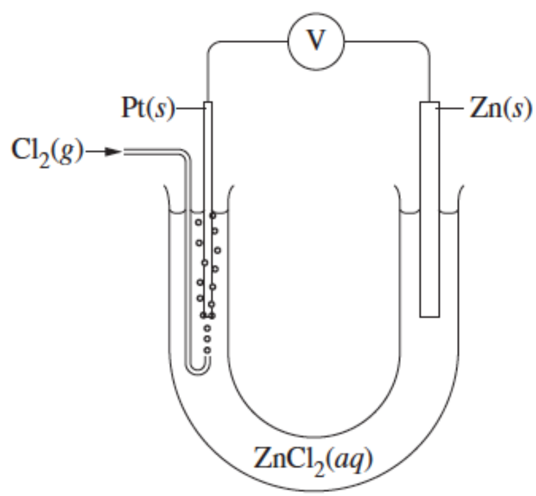
Question 28
After the cell has operated for a time, ion migration through the porous barrier has taken place. What observation would be expected from the resulting mixtures?

A. A solid would form on the silver electrode.
B. A precipitate would form in both half-cells.
C. A precipitate would form in the silver half-cell only.
D. A precipitate would form in the chlorine half-cell only.

Question 29
When a lead acid battery is recharging

A. the concentration of sulfuric acid electrolyte is decreasing
B. the pH of the electrolyte is increasing
C. the pH of the electrolyte is decreasing
D. the concentration of the sulfuric acid is the same concentration as when discharging.

Question 30
An experiment was set up as shown.



Which of the following statements is correct?

A. The chlorine gas is the anode.
B. The zinc electrode is the anode.
C. The platinum electrode is the anode.
D. There is no anode because there is no salt bridge.

END OF SECTION A

SECTION B

Specific Instructions for Section B

Section B consists of 13 short answer questions (question 1 to 13). You must answer all of these questions. The section is worth 76 marks or approximately 72% of the total.
Questions should be answered in the spaces provided in this booklet.
You should
* give simplified answers with the appropriate number of significant figures. Unsimplified answers will not receive full marks.
* Show all working in your answers to numerical problems. No marks can be given unless accompanied by working.
* make sure all chemical equations are balanced and that formulas for individual substances include an indication of state. Eg $H_2(g)$, NaCl (s).

Question 1 (7 marks)
A 20.72 g sample of solid lead was placed into 0.100 L of 1.00 M silver nitrate solution.

(a) Complete the table. Show relevant calculations in the space below the table. (5 marks)

Chemical species	$Pb^{2+}(aq)$	$Pb(s)$	$Ag^{+}(aq)$	$Ag(s)$	$NO_3^{-}(aq)$
Moles in final mixture					
Balanced chemical equation					

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b) With reference to only ONE species in the product mixture, explain why care must be taken in disposing of the final mixture. (2 marks)

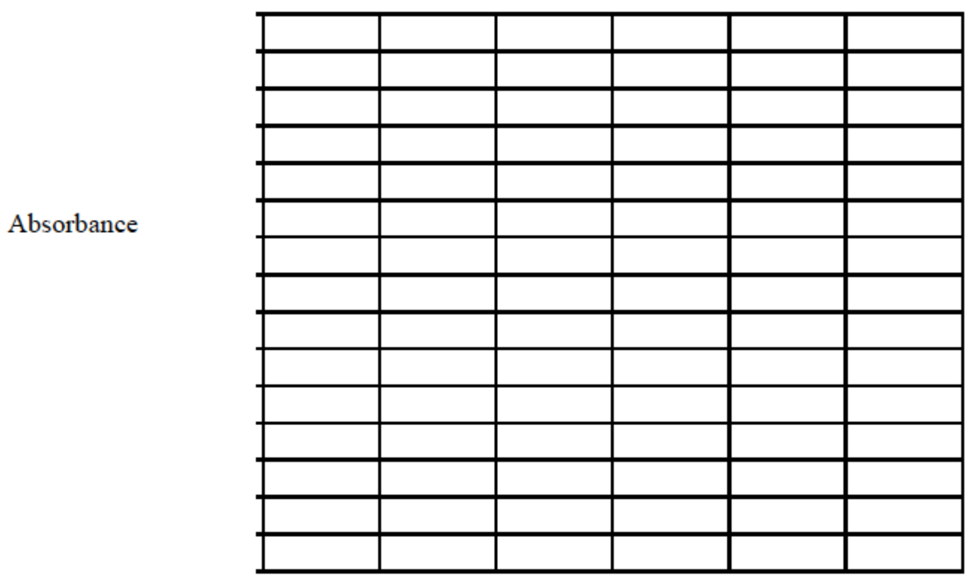
Question 2 (4 marks)

A 0.520 g sample of an alloy of silver and copper was dissolved in nitric acid.
The resulting solution required the addition of 41.5 mL of 0.0993 M sodium chloride solution to completely precipitate the silver ions.
Determine the percentage by mass of silver in the alloy. (4 marks)

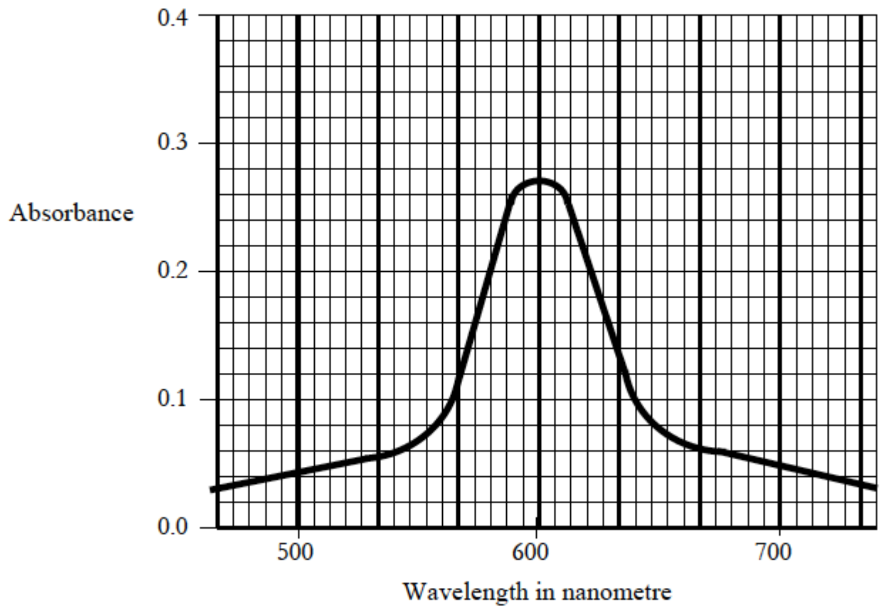
Question 3 (7 marks)
Standard solutions of a coloured dye solution were prepared and absorbance measurements taken using a UV-visible spectrophotometer.

Concentration ($mol\ L^{-1}$)	**Absorbance**
0.0050	0.12
0.010	0.23
0.015	0.35
0.020	0.46
0.025	0.57

a) On the axis provided below construct a calibration curve for the standard dye solutions.
(2 marks)



b) A 1.000ml sample of the dye was analysed. The sample was diluted up to 100.0ml with distilled water. The spectrum below was obtained using the diluted sample.



Use the calibration curve and the spectrum of the diluted dye to determine the concentration of the original dye solution. (3 marks)

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c) i) What is the most suitable wavelength for this determination? ___________________ nm. (1 mark)

ii) Explain why this wavelength was chosen. (1 mark)

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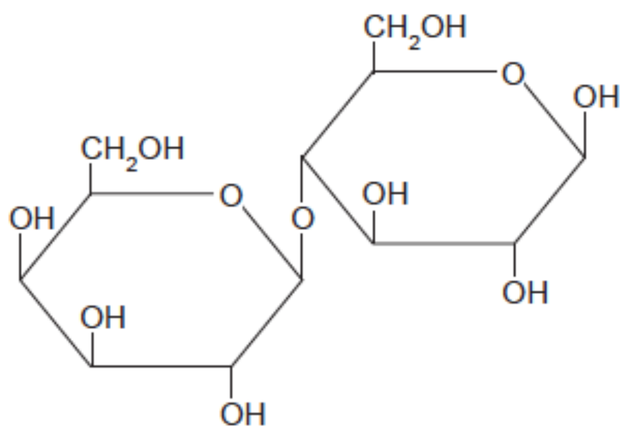
Question 4 (8 marks)
The enzyme lactase is able to convert the sugar lactose into glucose and galactose.

a) Lactose, which has the structural formula shown below, consists of the two linked 6-carbon sugar molecules, glucose and galactose:



(i) State the name given to a carbohydrate that consists of two linked sugar molecules. (1 mark)

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(ii) Name the type of reaction in which lactose is converted into glucose and galactose. (1 mark)

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(iii) State the molecular formula of galactose. (1 mark)

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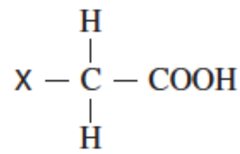
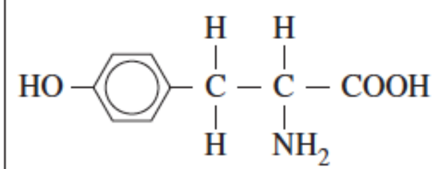
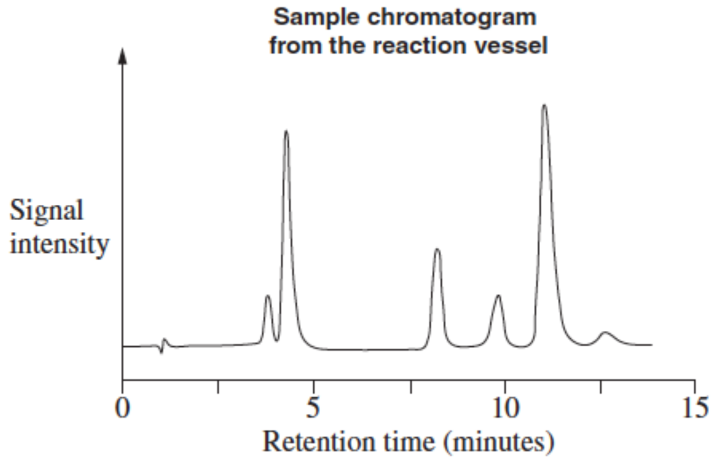
(b) The table below gives the abbreviation and structural formulae for two amino acids.
Part of the glycine molecule has been replaced by X.

Name	*Abbreviation*	*Formula*
Glycine	Gly	
Tyrosine	Tyr	

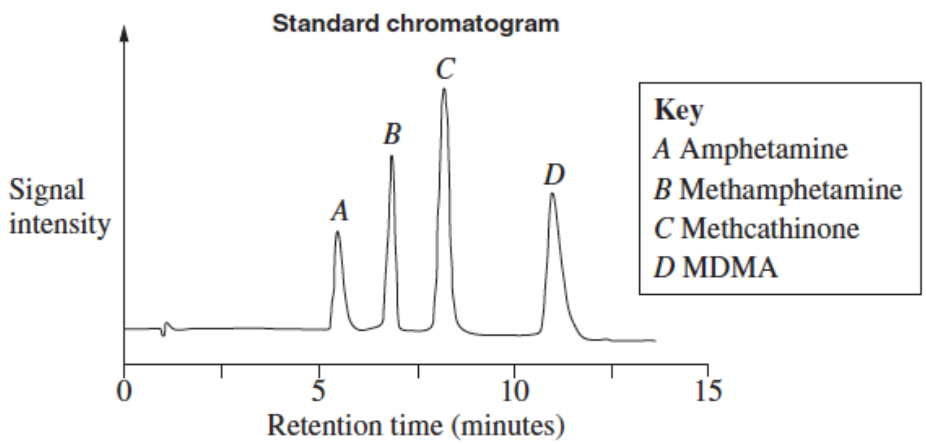
(i) Write an equation using the correct structural formulae showing the formation of a dipeptide between glycine and tyrosine. (2 marks)

(ii) Explain, in terms of chemical bonding, how the three-dimensional shape of a protein depends upon its primary structure. (3 marks)

Question 5 (3 marks)
A sample was collected from inside a reaction vessel at a suspected illegal drug laboratory. The sample was analysed by high performance liquid chromatography (HPLC). The chromatogram obtained from the collected sample is provided below.



The chromatogram of a standard mixture containing four compounds commonly produced in illegal drug laboratories is also provided.



By referring to the chromatograms, explain how this information could be used as evidence to support a guilty verdict in a court case. (3 marks)

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Question 6 (4 marks)

Consider this chemical system which is at equilibrium.

$$X(g) + Y(g) \rightleftharpoons Z(g) + heat$$

a) Explain the effect of decreasing the volume of the reaction vessel. (2 marks)

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b) Explain the effect of adding a catalyst to this equilibrium mixture. (2 marks)

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Question 7 (5 marks)

A calorimeter was calibrated by passing a 5.00 A current through it at 4.00 V for five minutes.
The temperature of the calorimeter increased by 15.0 °C.
The calibrated calorimeter was then used to determine the molar heat of solution of potassium hydroxide.
When 5.00 g of potassium hydroxide, KOH, was dissolved in water in the calorimeter, the temperature increased from 20.0 °C to 32.8 °C.

a) Determine the energy absorbed by the calorimeter and its contents when heated. (1 mark)

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b) Determine the calibration factor. (1 mark)

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c) Determine the energy released when 5.00 g of KOH dissolves. (1 mark)

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d) Determine the molar heat of solution of potassium hydroxide in kJ mol^{-1} . (2 marks)

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Question 8 (8 marks)

'Instant cold packs' can be used to treat some injuries.
In the past, 'instant cold packs' were made up of two bags. The first bag contained granules of ammonium nitrate, $NH_4NO_3(s)$, and inside it was another bag containing water.
When the bag containing water was broken the granules of ammonium nitrate started to dissolve and the 'instant cold pack' cooled.

a) What type of thermochemical reaction occurred? (1 mark)

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b) In terms of bond breaking and bond formation, explain why the temperature dropped as the ammonium nitrate dissolved. (3 marks)

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c) Sketch an enthalpy diagram for the process by which the ammonium nitrate dissolves.
Label the relevant features. (2 marks)

d) Suggest why the ammonium nitrate was used in a granulated form rather than a powdered form or as large chunks. (2 marks)

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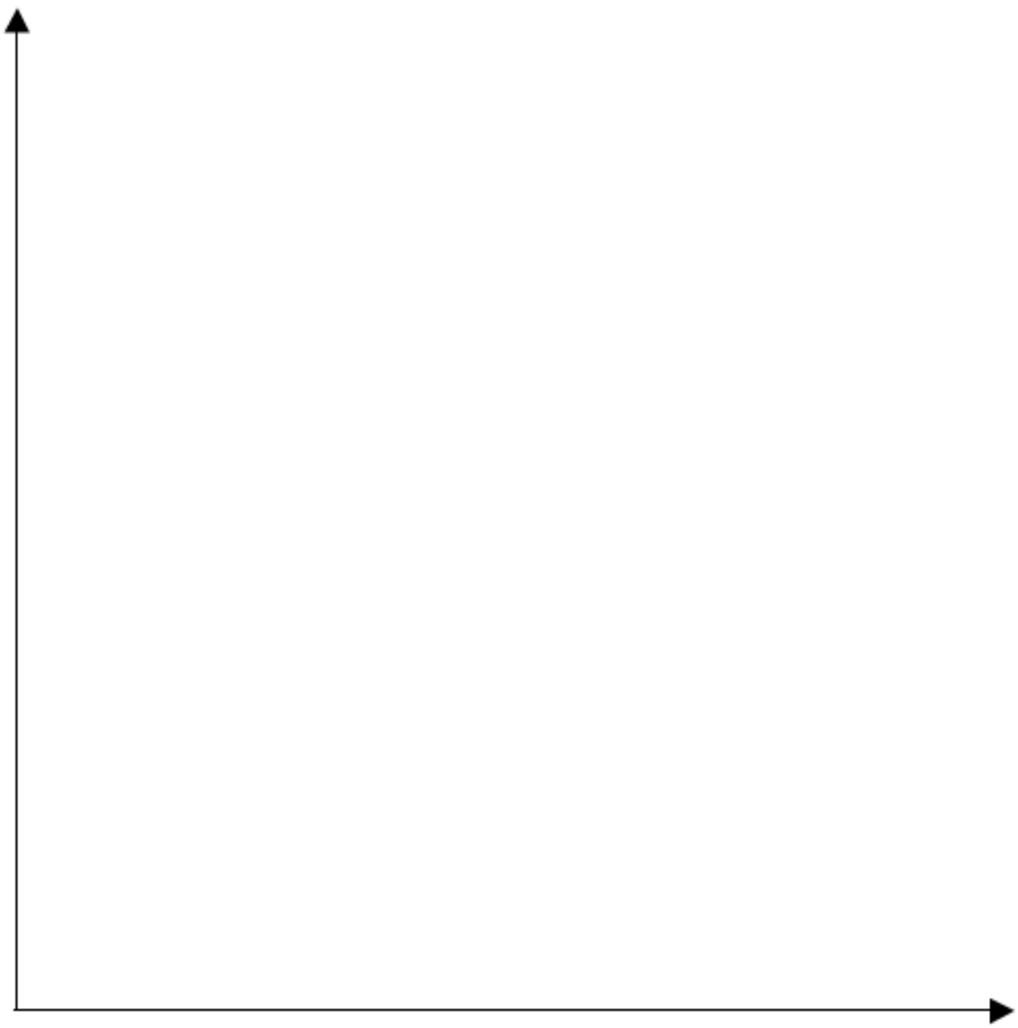
Question 9 (4 marks)

The following reaction has an activation energy of 360 kJ.

$CO_2(g) + NO(g) \rightarrow CO(g) + NO_2(g)$ $\Delta H = +220 kJ\ mol^{-1}$

Consider the **reverse reaction**.

a) Draw a reaction potential energy diagram for the reverse reaction in which NO(g) and CO_2(g) are produced. Give the values of the activation energy and the enthalpy change. (3 marks)

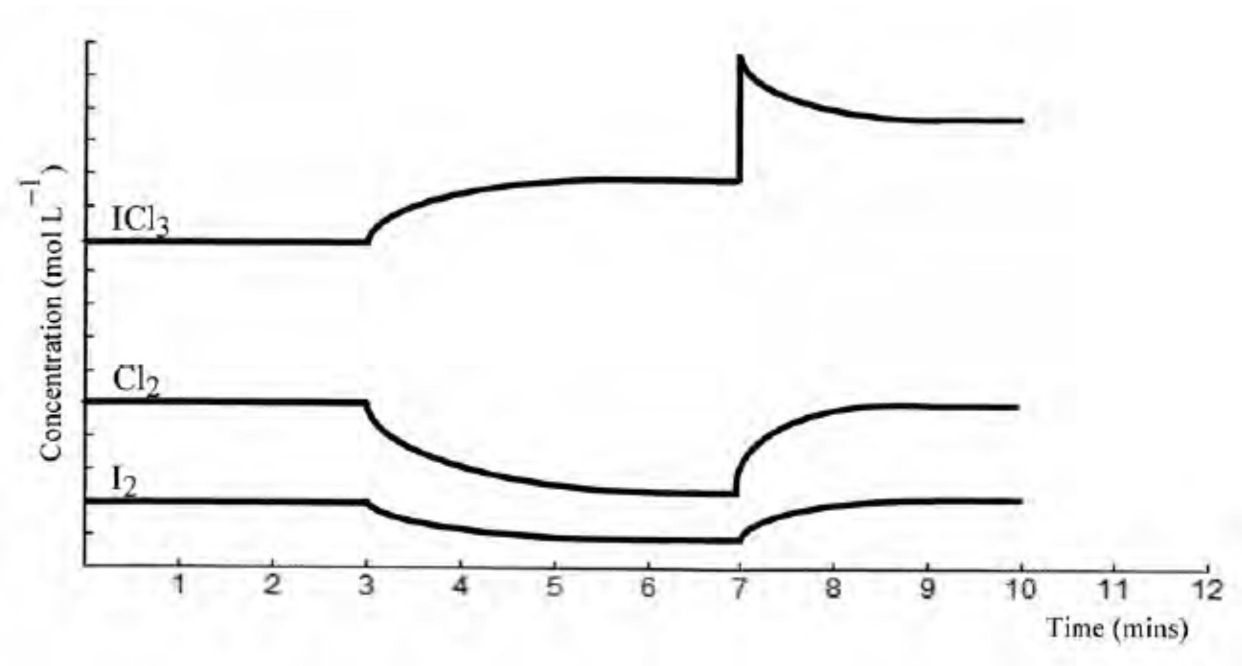


b) On the diagram above show the effect of adding a catalyst for the reaction. (1 mark)

Question 10 (7 marks)

Consider the graphical representation below of concentrations versus time for:

$$2ICl_3(g) \leftrightarrow I_2(g) + 3Cl_2(g) \qquad \Delta H = +240\ kJmol^{-1}$$



Identify and explain the changes to the equilibrium at the following time periods: (4 marks)

a) 3 minutes.

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b) 7 mintues.

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c) After 10 minutes the reaction vessel is compressed, reducing the volume. Equilibrium is re-established by 12 minutes. Explain the effect of this compression on the equilibrium.
Draw this effect on the graph on page 28. (3 marks)

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Question 11 (5 marks)
In a closed system, carbon oxyfluoride gas, $COF_2(g)$, partially decomposes to carbon tetrafluoride gas, $CF_4(g)$, and carbon dioxide gas in an equilibrium reaction.

a) Write the balanced chemical equation for this equilibrium reaction. (1 mark)

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The reaction is carried out at 250 °C in a 20.0 L container, starting with 4.40 moles of carbon oxyfluoride gas. At equilibrium 1.32 moles of the carbon oxyfluoride remains.

b) Determine the value of the equilibrium constant. (5 marks)

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c) Some extra carbon oxyfluoride gas, COF_2, is added to the container.
When equilibrium has been re-established and the temperature returned to 250 °C the concentration of carbon tetrafluoride, CF_4 , was 0.300 M . Determine the concentration of carbon oxyfluoride gas $COF_2(g)$.
(3 marks)

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Question 12 (8 marks)
A student electrolyses a 1.0 M magnesium nitrate solution using carbon electrodes in order to try to produce magnesium metal.
After a short time the student observes that no magnesium has formed and gas has evolved at both electrodes.

a) Explain why magnesium ions will not be reduced under these conditions. (2 marks)

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b) Suggest an alternative electrolytic process that would produce magnesium metal. Give a relevant half equation as part of your answer. (2 marks)

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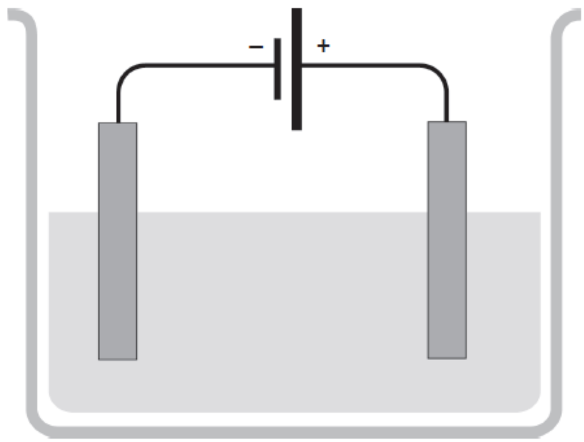
Question 13 (16 marks)

A quantity of pure chromium chloride ($CrCl_3$) is melted and placed in a heatproof vessel. Two inert electrodes are inserted as shown below and a current flows through the molten liquid.

a) Complete and label the diagram below, showing the:

- anode
- cathode
- direction of electron current
- ions present and the direction in which they are flowing. (5 marks)



b) Write the oxidation half equation. (2 marks)

c) Write the reduction half equation. (2 marks)

d) Write the overall redox equation. (2 marks)

continued

e) The electrolytic cell described above operates for 1.50 hours at a constant current of 18.5 A.

i. Calculate the quantity of electricity, in coulomb, that passes through the cell. (1 mark)

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ii. Assuming that 80.0% of the electricity passing through the cell is used in the electrolysis of $CrCl_3$, calculate the mass, in grams, of chromium produced in this time. (4 marks)

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END OF EXAM

Physical constants

$F = 96\ 500\ C\ mol^{-1}$
$R = 8.31\ J\ K^{-1}\ mol^{-1}$
1 atm = 101 325 Pa = 760 mmHg
0°C = 273 K
Molar volume at STP = 22.4 L mol^{-1}
Avogadro constant = $6.02 \times 10^{23}\ mol^{-1}$

Ideal gas equa
$pV = nRT$

The electrochemical series

	E° in volt
$F_2(g) + 2e^- \rightarrow 2F^-(aq)$	+2.87
$H_2O_2(aq) + 2H^+(aq) + 2e^- \rightarrow 2H_2O(l)$	+1.77
$Au^+(aq) + e^- \rightarrow Au(s)$	+1.68
$Cl_2(g) + 2e^- \rightarrow 2Cl^-(aq)$	+1.36
$O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(1)$	+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
$S(s) + 2H^+(aq) + 2e^- \rightarrow H_2S(g)$	+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

Periodic table of the elements

1 **H** 1.0																	2 **He** 4.0
3 **Li** 6.9	4 **Be** 9.0											5 **B** 10.8	6 **C** 12.0	7 **N** 14.0	8 **O** 16.0	9 **F** 19.0	10 **Ne** 20.1
11 **Na** 23.0	12 **Mg** 24.3											13 **Al** 27.0	14 **Si** 28.1	15 **P** 31.0	16 **S** 32.1	17 **Cl** 35.5	18 **Ar** 39.9
19 **K** 39.1	20 **Ca** 40.1	21 **Sc** 44.9	22 **Ti** 47.9	23 **V** 50.9	24 **Cr** 52.0	25 **Mn** 54.9	26 **Fe** 55.9	27 **Co** 58.9	28 **Ni** 58.7	29 **Cu** 63.6	30 **Zn** 65.4	31 **Ga** 69.7	32 **Ge** 72.6	33 **As** 74.9	34 **Se** 79.0	35 **Br** 79.9	36 **Kr** 83.8
37 **Rb** 85.5	38 **Sr** 87.6	39 **Y** 88.9	40 **Zr** 91.2	41 **Nb** 92.9	42 **Mo** 95.9	43 **Tc** 98.1	44 **Ru** 101.1	45 **Rh** 102.9	46 **Pd** 106.4	47 **Ag** 107.9	48 **Cd** 112.4	49 **In** 114.8	50 **Sn** 118.7	51 **Sb** 121.8	52 **Te** 127.6	53 **I** 126.9	54 **Xe** 131.3
55 **Cs** 132.9	56 **Ba** 137.3	57 **La** 138.9	72 **Hf** 178.5	73 **Ta** 180.9	74 **W** 183.8	75 **Re** 186.2	76 **Os** 190.2	77 **Ir** 192.2	78 **Pt** 197.0	79 **Au** 197.0	80 **Hg** 200.6	81 **Tl** 204.4	82 **Pb** 207.2	83 **Bi** 209.0	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** (226)	89 **Ac** (227)															

Lanthanides

58 **Ce** 140.1	59 **Pr** 140.9	60 **Nd** 144.2	61 **Pm** (145)	62 **Sm** 150.3	63 **Eu** 152.0	64 **Gd** 157.2	65 **Tb** 158.9	66 **Dy** 162.5	67 **Ho** 164.9	68 **Er** 167.3	69 **Tm** 168.9	70 **Yb** 173.0	71 **Lu** 175.0

Actinides

90 **Th** 232.0	91 **Pa** 231.0	92 **U** 238.0	93 **Np** 237.1	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (254)	100 **Fm** (257)	101 **Md** (258)	102 **No** (255)	103 **Lr** (256)

3. Physical constants

Avogadro's constant (N_A) $= 6.02 \times 10^{23}$ mol^{-1}

Charge on one electron $= -1.60 \times 10^{-19}$ C

Faraday constant (F) $= 96\,500$ C mol^{-1}

Gas constant (R) $= 8.31$ J K^{-1}mol^{-1}

Ionic product for water (K_w) $= 1.00 \times 10^{-14}$ mol^2 L^{-2} at 298 K
(Self ionisation constant)

Molar volume (V_m) of an ideal gas at 273 K, 101.3 kPa (STP) $= 22.4$ L mol^{-1}
Molar volume (V_m) of an ideal gas at 298 K, 101.3 kPa (SLC) $= 24.5$ L mol^{-1}

Specific heat capacity (c) of water $= 4.18$ J g^{-1} K^{-1}
Density (d) of water at 25 °C $= 1.00$ g mL^{-1}

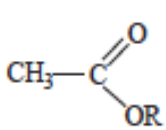
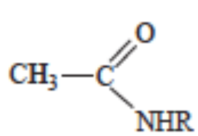
1 atm = 101.3 kPa = 760 mm Hg
0 °C = 273 K

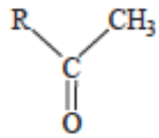
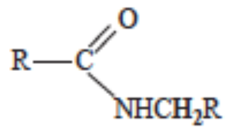
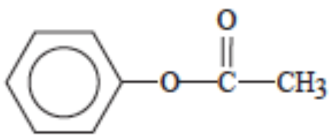
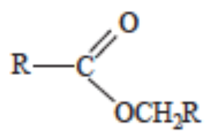
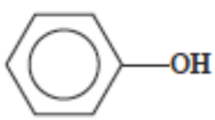
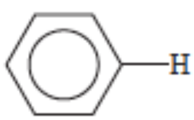
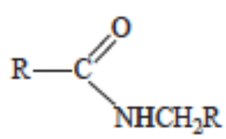
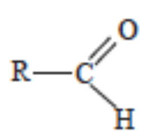
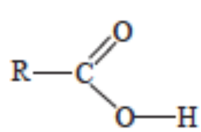
4. SI prefixes, their symbols and values

SI prefix	Symbol	Value
giga	G	10^9
mega	M	10^6
kilo	k	10^3
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}

5. ^{1}H NMR data

Typical proton shift values relative to TMS = 0
These can differ slightly in different solvents. Where more than one proton environment is shown in the formula, the shift refers to the ones in bold letters.

Type of proton	Chemical shift (ppm)
$R{-}CH_3$	0.8–1.0
$R{-}CH_2{-}R$	1.2–1.4
$RCH = CH{-}\mathbf{CH_3}$	1.6–1.9
$R_3{-}CH$	1.4–1.7
 or 	2.0

Type of proton	Chemical shift (ppm)
	2.1–2.7
$R–CH_2–X$ (X = F, Cl, Br or I)	3.0–4.5
$R–CH_2–OH$, $R_2–CH–OH$	3.3–4.5
	3.2
$R—O—CH_3$ or $R—O—CH_2R$	3.3
	2.3
	4.1
R–O–H	1–6 (varies considerably under different conditions)
$R–NH_2$	1–5
$RHC{=}CH_2$	4.6–6.0
	7.0
	7.3
	8.1
	9–10
	9–13

6. ^{13}C NMR data

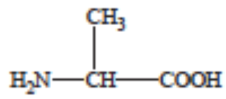
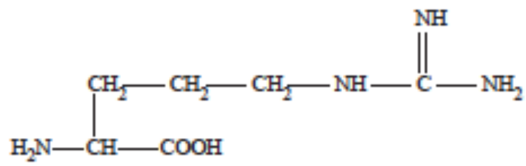
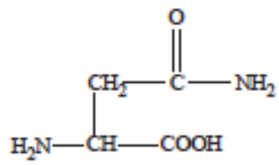
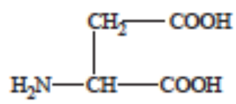
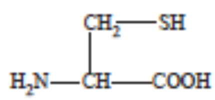
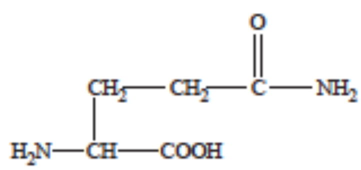
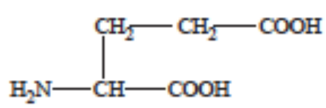
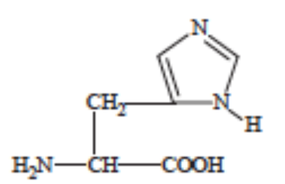
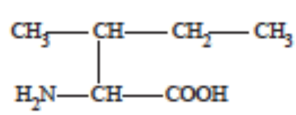
Type of carbon	Chemical shift (ppm)
$R–CH_3$	8–25
$R–CH_2–R$	20–45
$R_3–CH$	40–60
$R_4–C$	36–45
$R–CH_2–X$	15–80
$R_3C–NH_2$	35–70
$R–CH_2–OH$	50–90
RC≡CR	75–95
$R_2C=CR_2$	110–150
RCOOH	160–185

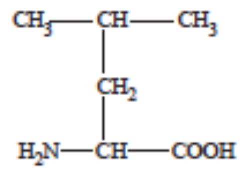
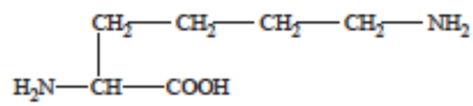
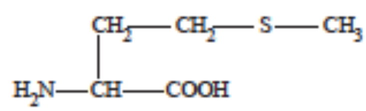
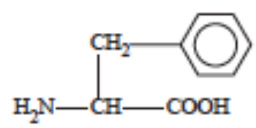
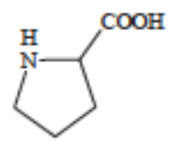
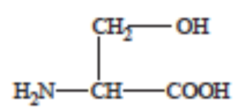
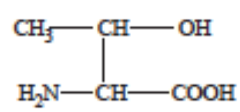
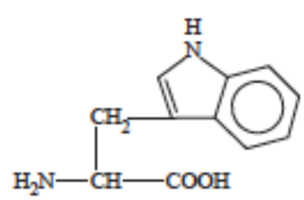
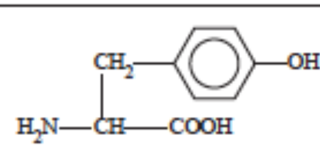
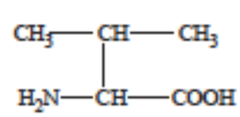
7. Infrared absorption data

Characteristic range for infrared absorption

Bond	Wave number (cm^{-1})
C–Cl	700–800
C–C	750–1100
C–O	1000–1300
C=C	1610–1680
C=O	1670–1750
O–H (acids)	2500–3300
C–H	2850–3300
O–H (alcohols)	3200–3550
N–H (primary amines)	3350–3500

8. 2-amino acids (*α*-amino acids)

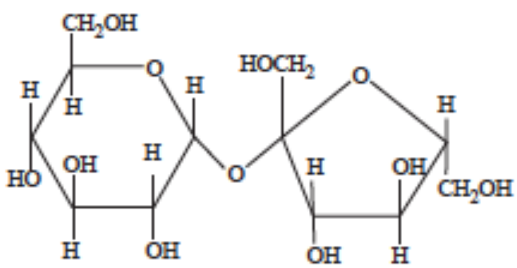
Name	Symbol	Structure
alanine	Ala	
arginine	Arg	
asparagine	Asn	
aspartic acid	Asp	
cysteine	Cys	
glutamine	Gln	
glutamic acid	Glu	
glycine	Gly	$H_2N—CH_2—COOH$
histidine	His	
isoleucine	Ile	

Name	Symbol	Structure
leucine	Leu	
lysine	Lys	
methionine	Met	
phenylalanine	Phe	
proline	Pro	
serine	Ser	
threonine	Thr	
tryptophan	Trp	
tyrosine	Tyr	
valine	Val	

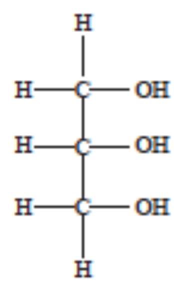
9. Formulas of some fatty acids

Name	Formula
Lauric	$C_{11}H_{23}COOH$
Myristic	$C_{13}H_{27}COOH$
Palmitic	$C_{15}H_{31}COOH$
Palmitoleic	$C_{15}H_{29}COOH$
Stearic	$C_{17}H_{35}COOH$
Oleic	$C_{17}H_{33}COOH$
Linoleic	$C_{17}H_{31}COOH$
Linolenic	$C_{17}H_{29}COOH$
Arachidic	$C_{19}H_{39}COOH$
Arachidonic	$C_{19}H_{31}COOH$

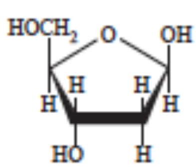
10. Structural formulas of some important biomolecules



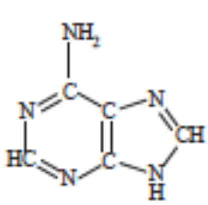
sucrose



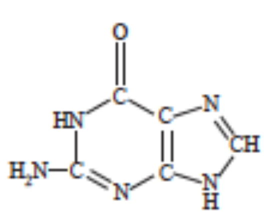
glycerol



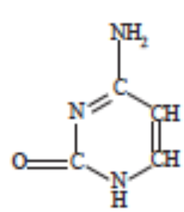
deoxyribose



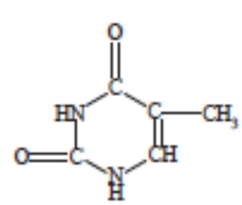
adenine



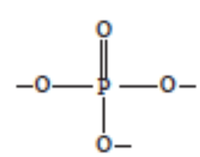
guanine



cytosine



thymine



phosphate

11. Acid-base indicators

Name	pH range	Colour change		K_a
		Acid	Base	
Thymol blue	1.2–2.8	red	yellow	2×10^{-2}
Methyl orange	3.1–4.4	red	yellow	2×10^{-4}
Bromophenol blue	3.0–4.6	yellow	blue	6×10^{-5}
Methyl red	4.2–6.3	red	yellow	8×10^{-6}
Bromothymol blue	6.0–7.6	yellow	blue	1×10^{-7}
Phenol red	6.8–8.4	yellow	red	1×10^{-8}
Phenolphthalein	8.3–10.0	colourless	red	5×10^{-10}

12. Acidity constants, K_a, of some weak acids at 25 °C

Name	Formula	K_a
Ammonium ion	NH_4^+	5.6×10^{-10}
Benzoic	C_6H_5COOH	6.4×10^{-5}
Boric	H_3BO_3	5.8×10^{-10}
Ethanoic	CH_3COOH	1.7×10^{-5}
Hydrocyanic	HCN	6.3×10^{-10}
Hydrofluoric	HF	7.6×10^{-4}
Hypobromous	$HOBr$	2.4×10^{-9}
Hypochlorous	$HOCl$	2.9×10^{-8}
Lactic	$HC_3H_5O_3$	1.4×10^{-4}
Methanoic	$HCOOH$	1.8×10^{-4}
Nitrous	HNO_2	7.2×10^{-4}
Propanoic	C_2H_5COOH	1.3×10^{-5}

13. Values of molar enthalpy of combustion of some common fuels at 298 K and 101.3 kPa

Substance	Formula	State	ΔH_c (kJ mol^{-1})
hydrogen	H_2	g	–286
carbon (graphite)	C	s	–394
methane	CH_4	g	–889
ethane	C_2H_6	g	–1557
propane	C_3H_8	g	–2217
butane	C_4H_{10}	g	–2874
pentane	C_5H_{12}	l	–3509
hexane	C_6H_{14}	l	–4158
octane	C_8H_{18}	l	–5464
ethene	C_2H_4	g	–1409
methanol	CH_3OH	l	–725
ethanol	C_2H_5OH	l	–1364
1-propanol	$CH_3CH_2CH_2OH$	l	–2016
2-propanol	$CH_3CHOHCH_3$	l	–2003
glucose	$C_6H_{12}O_6$	s	–2816

END OF DATA BOOK

CHEMOLOGY EDUCATION SERVICES

Name:______________________

CHEMISTRY Unit 3 & 4 Trial Exam
MULTIPLE CHOICE ANSWER SHEET

Colour the box after the letter corresponding to your answer.

1.	A☐	B☐	C☐	D☐	16.	A☐	B☐	C☐	D☐
2.	A☐	B☐	C☐	D☐	17.	A☐	B☐	C☐	D☐
3.	A☐	B☐	C☐	D☐	18.	A☐	B☐	C☐	D☐
4.	A☐	B☐	C☐	D☐	19.	A☐	B☐	C☐	D☐
5.	A☐	B☐	C☐	D☐	20.	A☐	B☐	C☐	D☐
6.	A☐	B☐	C☐	D☐	21.	A☐	B☐	C☐	D☐
7.	A☐	B☐	C☐	D☐	22.	A☐	B☐	C☐	D☐
8.	A☐	B☐	C☐	D☐	23.	A☐	B☐	C☐	D☐
9.	A☐	B☐	C☐	D☐	24.	A☐	B☐	C☐	D☐
10.	A☐	B☐	C☐	D☐	25.	A☐	B☐	C☐	D☐
11.	A☐	B☐	C☐	D☐	26.	A☐	B☐	C☐	D☐
12.	A☐	B☐	C☐	D☐	27.	A☐	B☐	C☐	D☐
13.	A☐	B☐	C☐	D☐	28.	A☐	B☐	C☐	D☐
14.	A☐	B☐	C☐	D☐	29.	A☐	B☐	C☐	D☐
15.	A☐	B☐	C☐	D☐	30.	A☐	B☐	C☐	D☐

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SUGGESTED SOLUTIONS TO 2014 CHEMISTRY UNIT 3 & 4 TRIAL EXAM

Section A

1 C	$[OH^-] = 10^{-3.8}$ n = CV = $10^{-3.8}$ x 0.1 m = n M = $10^{-3.8}$ x 0.1 x 40 = 1.67g	**16 B**	
2 D		**17 C**	Answer is C • C is correct. In pure water, [H3O+] must be equal to [OH–]. • A is incorrect because Kw is only 10–14 at 25°C. • B is incorrect because Kw changes with temperature. • D is incorrect because the [H3O+] must be equal to [OH–].
3 C	Needs to be diluted by 100 as each unit on pH scale is 10. pH 3 → 5 is 100 times. 10ml → 1000ml final volume (add 990ml water)	**18 B**	
4 B	$2Na + 2 H_2O \rightarrow 2NaOH + H_2$ 23g Na = 1mol $n(H_2)$ =0.5 mol pV = nRT V = nRT/p = (0.5 x 8.31 x 298)/100 = 12.38L	**19 C**	n(propanol) = 0.6 / 60 = 0.01molheat releasded for 0.01 mol = 2021 x 0.01 = 20.21kJ. E = m x C x ΔT 20210J =200 x 4.18 x ΔT ΔT = 24.17 Final Temp. = 24.17 + 21 = 45.2
5 A		**20 C**	T ↑ Δ H +ve T ↑
6 B	Same concentration of acid so will take the same volume to completely neutralise.	**21 B**	CO 1/28 = 0.036 mol **CH_4 1/16 = 0.063 mol – largest mol.** C_2H_2 1/26 = 0.038 mol C_2H_6 1/30 = 0.033 mol
7 D		**22 D**	Pressure decreases favours side with greater no. of mol. To the right.
8 D	C : H 81.8/12 : 18.2/1 6.82 : 2.67 3 : 8	**23 B**	T decreases, K increases if ΔH is negative. K increases, reaction moves to right. P decrease will favour side with greater no. of mol. In this case to right.
9 B	R_f = A/ solvent front 0.46 = 3.5/solvent front Solvent front = 7.6 R_f(B) = B/ 7.6 0.15 = B/7.6 **B = 1.14**	**24 A**	

10 B		**25 B**	Nitric acid would react with ammonia lowering its concentration. The equilibrium would shift to the left and become paler blue.
11 A		**26 C**	Q = I t = 10.72 x 15 x 60 = 9648 n(e) = Q/F = 9648 / 96500 = 0.10mol Cu^{2+} + 2e → Cu n(Cu) used = 0.1/2 = 0.05mol n(Cu) left = n(Cu) initially - n(Cu) used = (1.0 x 0.2) - 0.05 = 0.15mol $[Cu^{2+}]$ = 0.15/0.2 = 0.75M
12 C		**27 C**	Silver is a stronger reducatant than Cl^-
13 A		**28 B**	Chloride ions migrate to anode side and silver ions migrate to the cathode side. The presence of these ions in both half cells would cause precipate of silver chloride to form.
14 C	C An absorbance in the region around 3400 cm^{-1} is indicative of the hydroxy group, -OH, usually associated with alkanols, but could also include carboxylic acids. An absorbance in the 1700 cm^{-1} region is indicative of the C=O group. The absence of an absorbance in the 1700 cm^{-1} region eliminates responses A and D as both of these two compounds, butanoic acid and ethyl ethanoate, have a C=O moiety in their structures. Response B, diethyl ether, can be discounted as it does not have a hydroxy group.	**29 C**	
15 C	Answer is C Worked solution • C is correct. The 3 hydrogen atoms on each end are all equivalent. There are two neighbouring hydrogen atoms so the peak is split into n + 1 = 3, a triplet. The two middle hydrogen atoms are equivalent. They have 6 neighbouring hydrogen atoms, so the peak is split into a septet. • A is incorrect because the hydrogen atoms are not all equivalent. • B is incorrect because propane will not have a quartet. • D is incorrect because propane has two different hydrogen environments.	**30 B**	Zn is a stronger reductant. So it will undergo oxidation at the anode.

Section B ❶ = 1 mark

Question 1

a)

Sample answer:

$Pb(s) + 2AgNO_3(aq) \rightarrow Pb(NO_3)_2(aq) + 2Ag(s)$

$$n_{Pb} = \frac{20.72 \text{ g}}{207.2 \text{ g mol}^{-1}} = 0.1000 \text{ mol}$$

$$n_{Ag} = 0.100 \text{ L} \times 1.00 \text{ mol L}^{-1} = 0.100 \text{ mol}$$

Mole ratio Pb : $AgNO_3$ is 1 : 2

∴ 0.100 mol $AgNO_3$ and 0.0500 mol Pb used

Moles of remaining ions and solids

$Pb^{2+}(aq) = 0.0500$ mol $Ag^+(aq) = 0$ mol $NO_3^-(aq) = 0.100$ mol

$Pb(s) = 0.0500$ mol $Ag(s) = 0.100$ mol

b) Pb (s) is a toxic metal. It must not be disposed of down the sink. ❶

Question 2

Ag^+ (aq) + Cl^- (aq) → AgCl (s) ❶

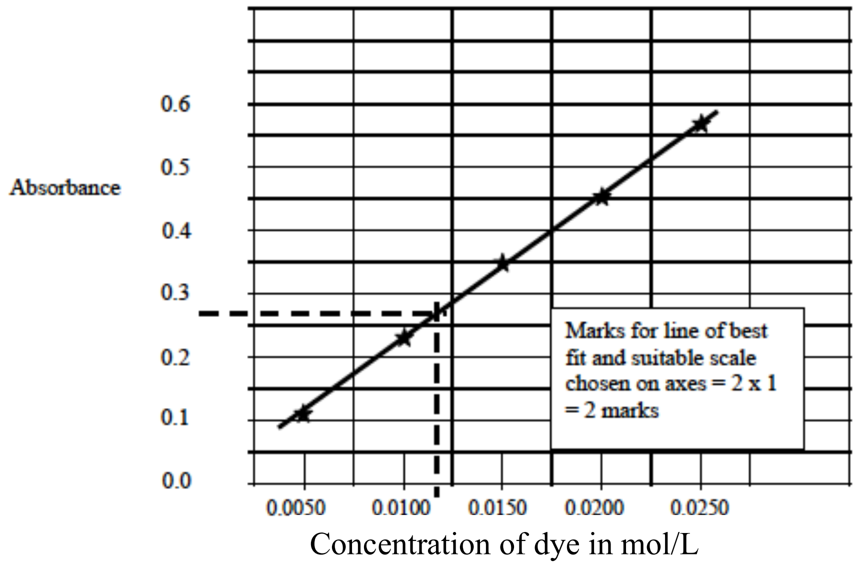
$n(Cl^-)$ = CV = 0.0993 x 0.0415 = 0.00412 mol = $n(Ag^+)$ = n(Ag) ❶

m(Ag) = nM = 0.00412 x 107.9 = 0.445g ❶

%Ag = [m(Ag) / m(alloy)] x 100 = (0.445/0.520) x 100 = **85.6%** ❶

Question 3

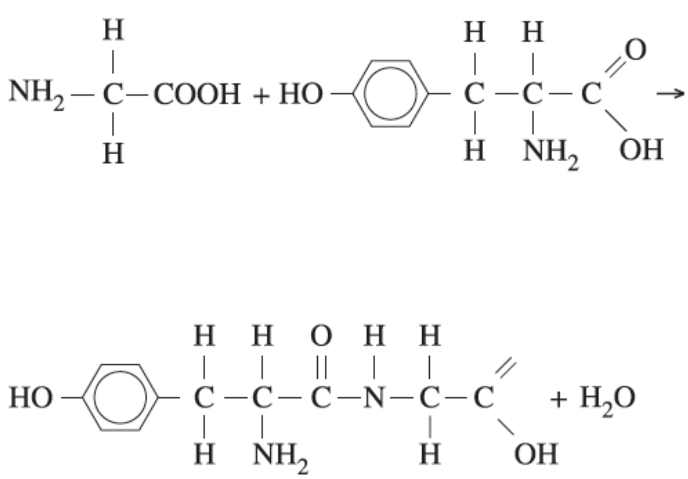
(a)



b) absorbance = 0.27 (+/- 0.01) ❶
Concentration of diluted dye is 0.012 M ❶
Concentration of dye = 0.012 x 100 = 1.2M ❶

c) From the spectrum it can be seen that this corresponds to the maximum absorbance value. ❶

Question 4
a) i) disaccharide ❶ ii) hydrolysis ❶ iii) $C_6H_{12}O_6$ ❶
b) i)



The primary structure of a protein is the sequence of amino acids that make up the protein. They are primarily linked by peptide bonds between carboxyl and amino functional groups.

However, the 3D shape of a protein is determined by side chains on the amino acid molecules. The sequence of amino acids will determine the side chains available to form subsidiary bonding between molecules.

Linkages include disulfide bridges, hydrogen bonding and electrostatic attractions which are all important in determining secondary shapes such as spirals, coils and sheets. The final 'tertiary' structure will be dependant upon these forces and any hydrophobic interactions caused by non-polar side chains.

Question 5

Sample answer:

Comparison between the standard and sample chromatograms indicates that the sample from the suspected drug laboratory contains Methcathinone and MDMA. This result confirms the drugs were being manufactured. Having established this result the forensic chemist may be requested to present this evidence in court. This will require the chemist to demonstrate the sample has not been contaminated and the chain of custody has been maintained at all times.

Answers could include:

Students may refer to the drugs as Drug C and Drug D.

Question 6

a) Decreasing the volume of the reaction vessel will increase the pressure. This will drive the reaction to the right hand side as there are fewer moles of gas on this side of the equation. ❶❶

b) Adding a catalyst to the equilibrium mixture will have no visible effect on the reaction mixture. This because a catalyst will speed up the rate of both the forward and back reactions. ❶❶

Question 7

a) Energy = V x I x t

= 5.00 x 4.00 x (5 x 60) = **6000 J** ❶

b) Calibration Factor = Energy / ΔT = 6000/15 = **400 J/^{0}C** ❶

c) Energy released for 5.00g = Cal. Factor x ΔT =400 x 12.8 = **5120 J** ❶

d) n(KOH) = 5.00/56.1 = 0.0891 mol ❶

5120 J for 0.0891 mol

x J for 1 mol

5120 / 0.0891 = 57463 kJ/mol ❶

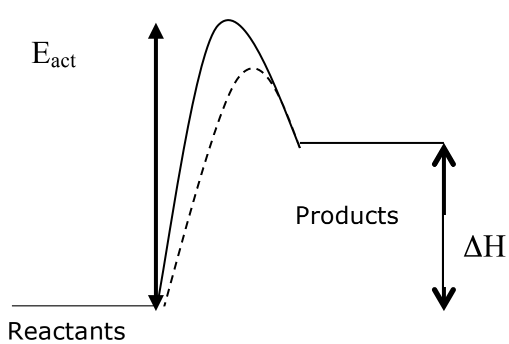
ΔH = - 57463 kJ/mol ❶

Question 8

a) Endothermic ❶

b) The energy released from bonds formed is less ❶than the energy absorbed breaking the original bonds, hence there is a **net absorption of energy**. ❶This energy is absorbed from the surroundings, hence the surroundings feel cooler. ❶

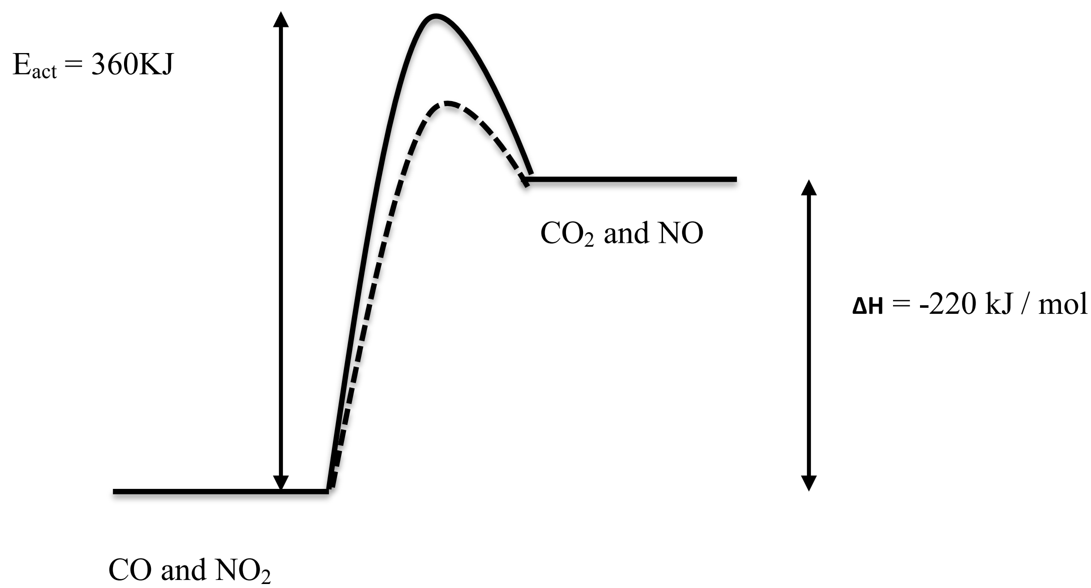
c)



❶ ❶

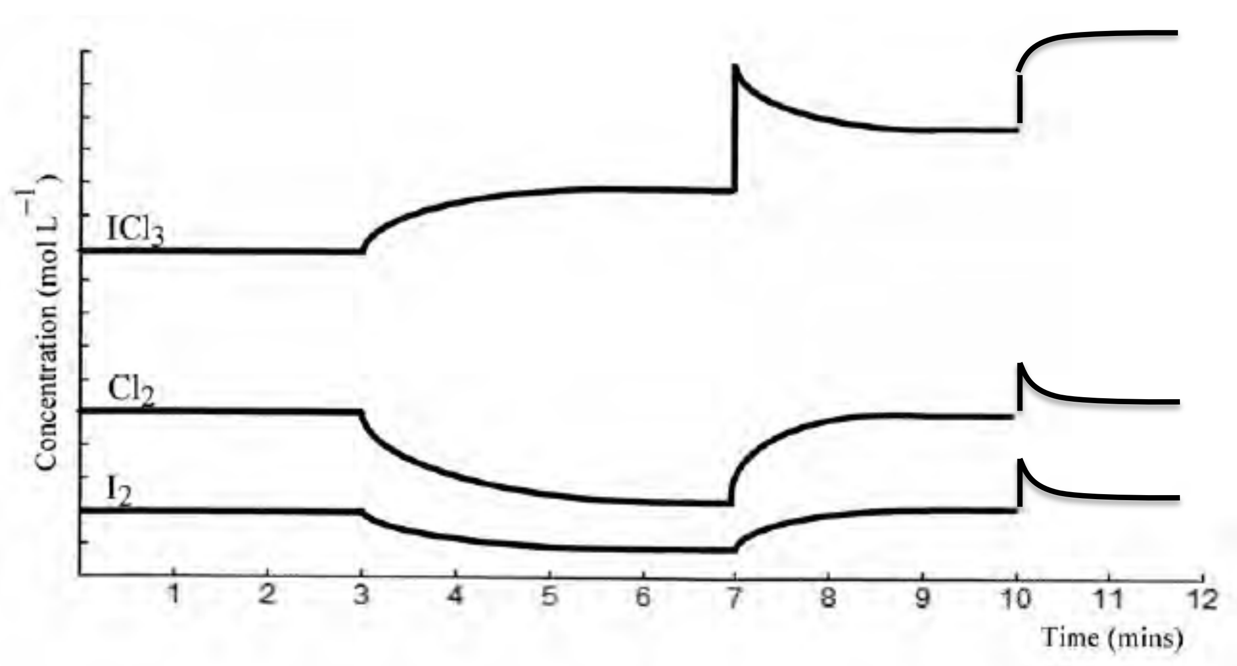
d) Granulated will be a larger surface area ❶ so a much faster reaction rate. ❶

Question 9



Question 10

a) Temperature decrease, K decrease due to reaction endothermic . Equilibrium shifts to left. ❶❶
b) Some IC_2 added to reaction mixture. Reaction moves forward. ❶❶
c) Volume decrease = Pressure increase causes reaction to move to side with fewer mole of particles, to the left. All concentrations will initially increase. ❶❶❶



Question 11

a) $2COF_2 \rightarrow CF_4 + CO_2$ ❶

b)

	$2COF_2$	CF_4	CO_2
Initial amount	4.4 mol	0	0
n(Reacting/ produced)	4.4 – 1.32 = **3.08 mol**	2 : 1 ratio ½ x 3.08 = **1.54 mol**	2 : 1 ratio ½ x 3.08 = **1.54 mol**
Mol Present at Equilibrium	1.32mol	0 + 1.54 = 1.54mol	0 + 1.54 = 1.54mol
Conc. at Equlibrium	1.32 / 20.0L = **0.066M**	1.54 / 20.0L = **0.077M**	1.54 / 20.0L = **0.077M**

$$K = \frac{[CF_4] \times [CO_2]}{[COF_2]^2}$$

$$= \frac{0.077^2}{0.066^2}$$

= 1.36

c) K remains the same as temperature has not chnaged. ❶

$$K = \frac{[CF_4] \times [CO_2]}{[COF_2]^2}$$

$$1.36 = \frac{0.3 \times 0.3}{[COF_2]^2}$$

$$[COF_2]^2 = \frac{0.3 \times 0.3}{1.36}$$ ❶

$[COF_2]$ = **0.257M** ❶

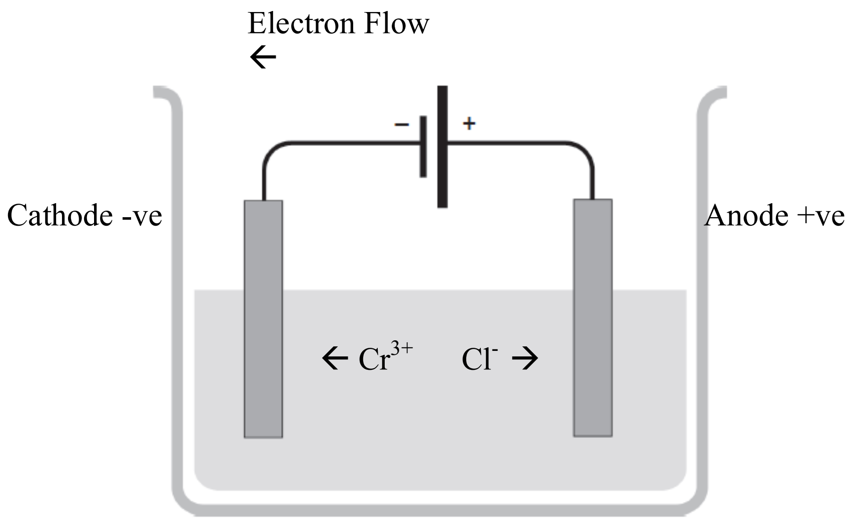
Question 12

a) Mg^{2+} ions are a weaker oxidant than water molecules. ❶Water will be preferentially oxidised. ❶

b) Need to have molten $MgNO_3$ or molten liquid with Mg^{2+} ions. ❶
Mg^{2+} (l) + 2 e $\rightarrow$ Mg (l) ❶ will form at the negative cathode in the electrolytic cell.

Question 13

a)



b) Cr^{3+} (l) + 3e → Cr (l) ❶❶

c) $2Cl^-$ (l) → Cl_2 (g) + 2e ❶❶

d) $2Cr^{3+}$ (l) + $6Cl^-$ (l) → 2Cr (l) + $3Cl_2$ (g) ❶❶

e)

Solution

$$Q = It$$
$$= 18.5 \times 1.50 \times 60 \times 60$$
$$= 9.99 \times 10^4 \text{ C}$$

Explanatory notes

Time must be expressed in seconds for use in this equation.

c) Amount of electricity used = 80% x 9.99 x 10^4 C = 7.99 x 10^4 C ❶

n(e) = Q/F = 7.99 x 10^4 C / 96 500 = 0.828 mol ❶

Cr^{3+} + 3e → Cr

n(Cr) = 1/3 x n(e) = 1/3 x 0.828 = 0.276 mol ❶

m(Cr) = n M = 0.276 x 52 = **14.3g** ❶