NAME: _____

Practice Examination

VCE Chemistry

Reading time: 15 minutes

Writing time: 90 minutes

QUESTION AND ANSWER BOOK

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	20	20	20
B	7	7	55
		Total	75

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers and one scientific calculator.
- Students are NOT permitted to bring into the examination room: blank sheets of paper and/or white out liquid/tape.

Materials supplied

- Question and answer book of 19 pages.
- A data book (provided by your teacher).
- Answer sheet for multiple-choice questions.

Instructions

- Write your **student name** in the space provided above on this page.
- Check that your **name** is printed on your answer sheet for multiple-choice.
- All written responses must be in English.

At the end of the examination

- Place the answer sheet for multiple-choice questions inside the front cover of this book.
- Return the data book to your teacher.

Students are NOT permitted to bring mobile phones and/or any other unauthorised electronic devices into the examination room.

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SECTION A- Multiple-choice questions

Instructions for Section A

Answer **all** questions in pencil on the answer sheet provided for multiple-choice questions by shading in your choice.
Choose the response that is **correct** or that **best answers** the question.
A correct answer scores 1, an incorrect answer scores 0.
Marks will **not** be deducted for incorrect answers.
No marks will be given if more than one answer is completed for any question.

Question 1

A solution calorimeter was accidently calibrated with 110 ml of distilled water instead of 100 ml. The calorimeter was emptied, dried and then used to determine the heat of reaction of powdered magnesium in 100 ml of HCl. It can be deduced from this information that the correct calibration factor should be

A. higher and the heat of reaction should be lower.

B. higher and the heat of reaction should be higher.

C. lower and the heat of reaction should be higher.

D. lower and the heat of reaction should be lower.

Question 2

A catalyst is thought to increase the rate of a chemical reaction by

A. increasing the temperature of the reaction.

B. providing more surface area for the reaction.

C. providing an alternative reaction pathway with lower activation energy.

D. supplying the energy needed to overcome the activation energy.

Question 3

A gas syringe contains an equilibrium mixture of the gases NO_2 and N_2O_4. $2NO_{2(g)} \rightleftharpoons N_2O_{4(g)}$ When the plunger is pushed inwards, all concentrations increase immediately. Which of the following will occur after the system experiences this change?

A. The concentration of NO_2 in the system decreases further while the concentration of N_2O_4 increases.

B. The concentration of NO_2 in the system increases further while the concentration of N_2O_4 decreases.

C. All concentrations decrease further in order to regain a new position of equilibrium.

D. All concentrations increase further in order to regain a new position of equilibrium.

Question 4

A button cell has the following reaction as current is drawn.

$Ag_2O_{(s)} + Zn_{(s)} + H_2O_{(l)} \rightarrow 2Ag_{(s)} + Zn(OH)_{(s)}$

In this cell $Ag_2O(s)$ forms the

A. positive electrode and is oxidised.

B. positive electrode and is reduced.

C. negative electrode and is oxidised.

D. negative electrode and is reduced.

Question 5

A solution is made by dissolving 1.139 g of solid barium hydroxide in distilled water and then adding more distilled water until the total volume of the solution is one litre. The molarity of the barium hydroxide solution, the hydroxide concentration in mol dm^{-3} and the pH of the solution would be closest to

A. 0.01M, 0.02M, 12.3

B. 0.02M, 0.01M, 12.3

C. 12.3, 0.01M, 0.02M

D. 0.02M, 12.3, 0.01M

Question 6

The overall cell potential of the galvanic cell constructed from a Cu^{2+}/Cu electrode and a Mg^{2+}/Mg electrode under standard conditions would be expected to be

A. O.34V

B. -2.34V

C. 2.68V

D. -2.00V

Question 7

In the production of copper and aluminium by electrolysis, when the same quantity of electricity is passed through the cells, the simplest ratio of the **mass** of copper deposited compared to the **mass** of aluminium deposited would be

A. 1:1

B. 4:3

C. 7:2

D. 8:9

Question 8

The best explanation for the fact that at higher temperatures the rate of most chemical reactions increases is that the

A. shape of the colliding particles is more suitable to react.

B. activation energy for the reaction is decreased.

C. colliding particles have sufficient energy to react.

D. orientation of the colliding particles is more suitable to react.

Question 9

Plants use energy from the sun, along with carbon dioxide and water during the process of photosynthesis according to the equation:

$6CO_{2(g)} + 6H_2O_{(l)} \rightarrow C_6H_{12}O_{6(aq)} + 6O_{2(g)}$ (in the presence of UV light and Chlorophyll)

The total chemical energy of the products in this reaction is

A. greater than that of the reactants and the reaction is exothermic.

B. less than that of the reactants and the reaction is exothermic.

C. less than that of the reactants and the reaction is endothermic.

D. greater than that of the reactants and the reaction is endothermic.

Question 10

Which of the following acids will show the greatest percentage ionization in solution?

A. Benzoic

B. Lactic

C. Hydrocyanic

D. Hypobromous

Question 11

Magnesium reacts with oxygen according to the thermochemical equation

$2Mg_{(s)} + O_{2(g)} \rightarrow 2MgO_{(s)} \quad \Delta H = -1200\ kJmol^{-1}$

The mass, in grams, of magnesium that would need to react to release 8000 kJ of energy is

A. 162

B. 3.65

C. 324

D. 1.8

Question 12

A 1.00M solution of zinc chloride was electrolysed using graphite electrodes. In this electrolytic cell water is acting as

A. a solvent.

B. a reductant and a solvent.

C. an oxidant and a solvent.

D. a solvent, a reductant and an oxidant.

Question 13

Which of the procedures below is likely to decrease the rate of the following reaction?

$2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)} \quad \Delta H = -191kJ\ mol^{-1}$

A. Increasing the temperature

B. Adding vanadium pentoxide as a catalyst

C. Decreasing the volume of the reaction vessel

D. Using air instead of pure oxygen

Question 14

Water undergoes self-ionisation according to the equation below:

$H_2O_{(l)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + OH^-_{(aq)} \quad \Delta H > 0$

The pH of pure water is 7 at 25^0C. What would the pH of pure water be at 30^0C?

A. Less than 7

B. Greater than 7

C. Equal to 7

D. Unable to tell from the information given

Question 15

Which of the following metals cannot be extracted commercially from their aqueous solutions?

A. Copper

B. Nickel

C. Potassium

D. Tin

Question 16

Which of the following is **not** an example of using the principles of green chemistry?

A. Reducing the use of toxic chemicals by replacing them with safer alternatives

B. Maximising the atom efficiency of each of the reaction pathways

C. Reducing the formation of wastes and by-products

D. Maximising the energy usage in each chemical process

Question 17

Hydrogen gas has been proposed as a fuel of the future. Research and development has enabled it to be used to power a motor car but there are however, still some problems with its use. Which of the following is true for hydrogen gas?

A. The products of combustion have stronger bonds than hydrogen gas

B. It has a very high energy per gram

C. The infrastructure is still not available for extensive use as an alternative fuel for cars

D. All of the above

Question 18

Nitric acid ionises in water according to the equation below:

$HNO_{3(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + NO_3^-{}_{(aq)}$

The equilibrium constant for this reaction at 25^0C is K.

What is the value for the equilibrium constant at 25^0C for the reaction below?

$2H_3O^+_{(aq)} + 2NO_3^-{}_{(aq)} \rightleftharpoons 2HNO_{3(aq)} + 2H_2O_{(l)}$

A. 2K

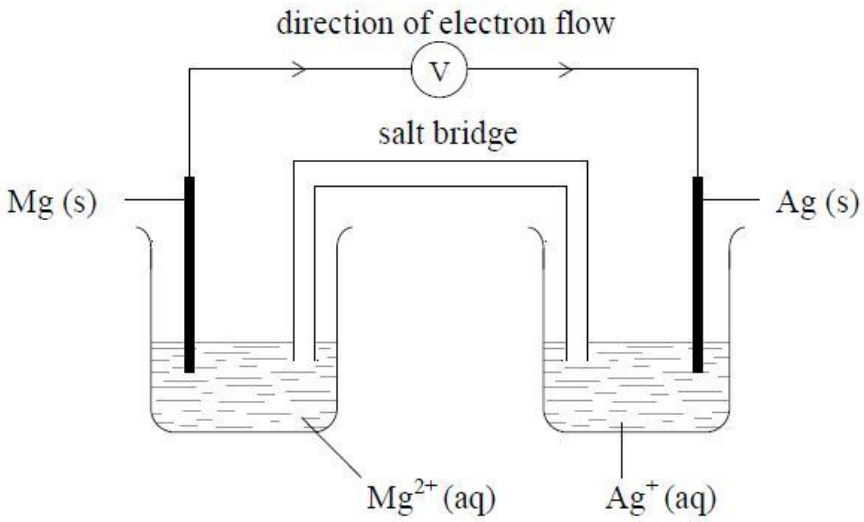
B. ½ K

C. $1/K^2$

D. $K^2/2$

Question 19

The next two questions refer to the galvanic cell shown below.



In the galvanic cell

A. the Ag electrode is the anode and Ag^+ ions are reduced.

B. the Mg electrode is the anode and has a negative charge.

C. the Mg electrode is the cathode and Mg2+ ions are reduced.

D. the Ag electrode is the cathode and has a negative charge.

Question 20

If the salt bridge was soaked in a saturated solution of KNO_3, then as the cell discharges

A. K^+ ions would migrate towards the half- cell containing the Mg electrode.

B. K^+ ions would migrate towards the half-cell containing the Ag electrode.

C. NO_3^- ions would migrate to the half-cell containing the Mg electrode.

D. Mg^{2+} ion would migrate towards the electrode containing the Mg electrode.

SECTION B- Short answer questions

Instructions for Section B

Answer **all** questions in the spaces provided in blue or black pen or pencil.
To obtain full marks 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 marks.
- show all working in your answers to numerical questions. No credit will be given for an incorrect answer unless it is accompanied by details of the working.
- ensure chemical equations are balanced and that the formulas for individual substances include an indication of state for example $H_{2(g)}$ and $NaCl_{(s)}$.

Question 1

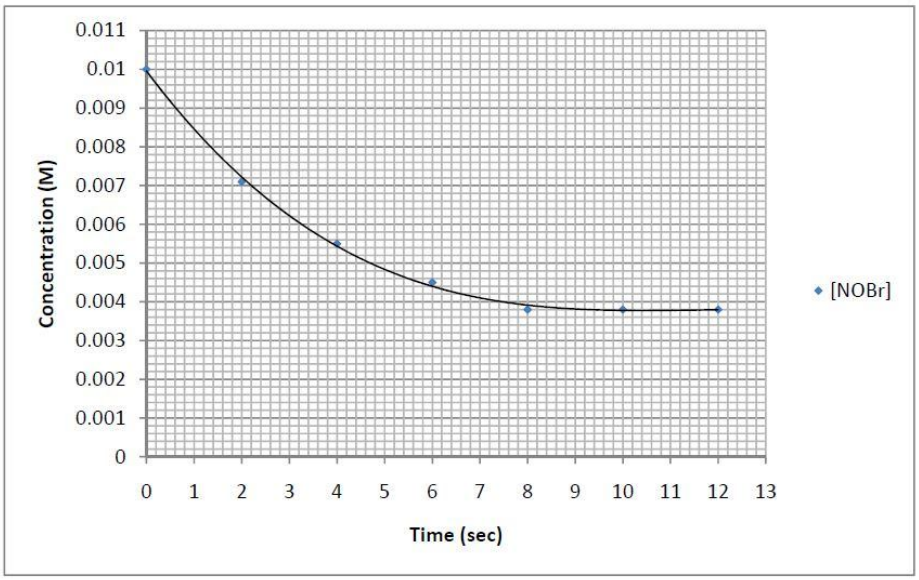
Nitrosyl bromide decomposes according to the following equation:

$$2NOBr_{(g)} \rightarrow 2NO_{(g)} + Br_{2(g)}$$

A student placed some nitrosylbromide in a container and used a manometer (an instrument for comparing pressures) to collect the data below.

Time (sec)	Concentration NOBr (M)
0	0.0100
2	0.0071
4	0.0055
6	0.0045
8	0.0038
10	0.0038
12	0.0038

The data collected was used to plot the following graph.



a) Determine the initial rate of reaction in terms of [NOBr] (1mark)

b) Determine the average rate of reaction in terms of [NOBr] for the first 8s. (1mark)

c) Why is the initial rate of reaction greater than the average rate over the first 8s? (1 mark)

_____

_____

_____

d) On the graph above, show how the concentration of Br_2 would change over the period of 10s.

(2 marks)

e) The student repeats the experiment this time using a higher pressure. This was achieved by decreasing the volume of the container at constant temperature. State what will happen to the reaction rate giving a reason for the observed change.

_____

_____

_____

_____

(2 marks)

f) An increase in pressure (by decreasing the volume) does not increase the rate of the following reaction type

$2XY_{(g)} \rightarrow X_{2(g)} + Y_{2(g)}$

Explain why and suggest two ways the reaction rate could be increased. (3 marks)

_____

_____

_____

_____

_____

Total 10 marks

Question 2

Methanoic acid, HCOOH is a weak acid.

a) Explain what is meant by the term 'weak acid'. (1 mark)

_____

_____

b) Determine the concentration of the methanoate ion, $HCOO^-$, in a 0.0500M solution of methanoic acid at 25^0C. (4 marks)

_____

_____

_____

_____

_____

_____

b) A base in water produces hydroxide ions by accepting a proton from water. An aqueous solution of a **weak** base, sodium methanoate, HCOONa, contains hydroxide ions. Write an **ionic** equation to describe this equilibrium reaction. (2 marks)

_____

_____

c) A basicity constant, K_b, can be calculated from the above equation. A K_b value is an indication of the extent of ionisation of a weak base. Write an expression for K_b of the methanoate ion. (1 mark)

_____

_____

Total 8 marks

Question 3

Chlorine and sodium hydroxide are produced by the electrolysis of concentrated sodium chloride. The net cell reaction can be represented by:

$2Cl^-_{(aq)} + 2H_2O_{(l)} \rightarrow Cl_{2(g)} + H_{2(g)} + 2OH^-_{(aq)}$

a) For each electrode, write the corresponding half equation. (2 marks)

Positive electrode:_____

Negative electrode:_____

b) i) Calculate the volume of chlorine gas that would be produced from 1.00 L of 10.0M sodium chloride solution. Assume that the gas is collected at a temperature of 298 K and a pressure of 101.3 kPa. (2 marks)

_____

_____

_____

_____

ii) Calculate the time (in hours) required to produce this volume of chlorine gas using a current of 20 A. (3 marks)

_____

_____

_____

_____

_____

_____

_____

_____

_____

→

c) What energy transformation/s is/are occurring when the electrolytic cell above is operating?

_____

_____

(1 mark)

Total 8 marks

Question 4

A caravan refrigerator has more than one source of energy. It is powered from either a 12V car battery or the 240V commercial electricity grid.

a) State whether each source of energy is renewable or non-renewable. (2 marks)

240V power supply:_____

12V car battery:_____

b) State **one advantage** and **one disadvantage** of using each energy source (4 marks)

ADVANTAGE

240V power supply:_____

12V car battery:_____

DISADVANTAGE

240V power supply:_____

12V car battery_____

Total 6 marks

Question 5

Two experiments were conducted in a bomb calorimeter to determine whether the extraction of aluminium or iron from their respective ores would require more energy. The calibration factor of the calorimeter and its contents was determined to be 1076 J $^0C^{-1}$.

In the first experiment, a 0.503g sample of aluminium was oxidised in the bomb calorimeter and the temperature rose by 5.84^{0}C.

a) Calculate the energy released (J) when the aluminium was oxidised in the calorimeter. (1 mark)

_____

_____

b) Calculate ΔH for the reaction: $2Al_{(s)} + 3/2O_{2\,(g)} \rightarrow Al_2O_{3(s)}$ (3 marks)

_____

_____

_____

_____

_____

_____

In the second experiment, a 0.561g sample of iron was oxidised in the same bomb calorimeter. The reaction was: $2Fe_{(s)} + 3/2O_{2(g)} \rightarrow Fe_2O_{3(s)}$ $\Delta H = -828kJ\ mol^{-1}$

c) Determine the temperature change that occurred during the second experiment. (3 marks)

_____

_____

_____

_____

_____

_____

→

d) Which metal, Aluminium or Iron, requires more energy to extract it from its ore? Give a reason for your choice. (2 marks)

_____

_____

_____

Total 9 marks

Question 6

For the reaction $2X_{(g)} + Y_{(g)} \rightleftharpoons 2Z_{(g)}$

The equilibrium constant K_c is equal to 3.0 at particular temperature. 2.0 mol of X and 3.0 mol of Y and 3.0 mol of Z are introduced into a 1.0L flask.

a) Write an expression for the equilibrium constant K_c (1 mark)

_____

_____

b) Prove the mixture is not at equilibrium . (2 marks)

_____

_____

_____

_____

→

c) If the volume of the equilibrium mixture was doubled, what effect would this have on the amount of reactant Y and the concentration of Y? Explain your answer. (3 marks)

_____

_____

_____

_____

_____

_____

Total 6 marks

Question 7

For the industrial chemical you have studied

a) Write the equation for the main equilibrium step involved including the sign of ΔH (2 marks)

_____

b) State **two** applications of the principles of green chemistry that has been used in the production of this chemical. (2 marks)

_____

_____

_____

_____

_____

_____

→

c) State **two** major uses for the chemical using equations to support the uses. (4 marks)

_____

_____

_____

_____

_____

_____

Total 8 marks

END OF QUESTIONS AND ANSWER BOOKLET

VCE CHEMISTRY

NAME: _____

Circle your choice using a pencil. If you make an error place a clear cross to eliminate that choice and then circle your preferred choice.

Multiple- choice answer sheet

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

Solution Pathway

SECTION A- Multiple-choice questions

1. **Correct Answer B.** If the same energy is supplied to a greater volume of water then the temperature change would be lower resulting in a higher CF; if CF is higher then, E = CF x ΔT will increase and the ΔH will increase.

2. **Correct Answer C.** The surface of a catalyst bonds with the reacting molecules to weaken the existing bonds within those reacting molecules lowering the activation energy of the reaction which then proceeds by a different pathway.

3. **Correct Answer A.** As V↓, P↑ so according to LCP the overall P must decrease to restore equilibrium. To do this there must be a net reaction to produce fewer particles so the reaction moves to the R to increase the concentration of N_2O_4 and decrease the concentration of NO_2.

4. **Correct Answer B**. Ag+ decreases in oxidation number from +1 to 0 and is therefore reduced. The silver oxide must gain electrons to be reduced to silver so it is the positive electrode (cathode) in an electrochemical/galvanic cell.

5. **Correct Answer A.**

   n($Ba(OH)_2$) =1.139/113.9 = 0.01 mol, c($Ba(OH_2)$ n/v 0.01/1 = 0.01M c(OH-) = 2c($Ba(OH_2)$ = 0.01 x 2= 0.02M, $[OH^-]$ = 0.02M = $10^{-1.69}$M, $[H_30^+]$ = $10^{-14}/10^{-1.69}$ = $10^{-12.31}$M, pH = -log10 $[H_30^+]$ = 12.31. Alternative A has the correct order.

6. **Correct Answer C.** The E^o_{cell} = E^o_{ox} - E^o_{red}, Cu^{2+} is the oxidant in this cell so

   E^0_{cell} = 0.34 - (-2.34) = 0.34 + 2.34 = 2.68V

7. **Correct Answer C.** Cu^{2+} + $2e^-$ → Cu; Al^{3+} + $3e^-$ → Al

   For the same number of mol. of electrons passing through the cell

   n(Cu) = 1.5 n(Al) = 1.0

   m(Cu) = n x M =1.5 x 63.6 = 95.4g m(Al) = n x M 1.0 x 27.0 = 27.0g

   m(Cu)/m (Al) = 95.4/27.0 3.53 Ratio = 7:2

8. **Correct Answer C.** Particles gain KE with an increase in temperature. This means that more of the reacting particles have sufficient energy greater than the E_A of the reaction. This increases the probability of more successful collisions and so increases the rate of reaction.

9. **Correct Answer D.** Photosynthesis is an endothermic process as it requires energy from the sun so the total energy of the products will be greater than the total energy of the reactants.

10. **Correct Answer B.** Lactic Acid has the highest Acidity constant, K_a of the four acids. This means it is the strongest and so will undergo the greatest percentage ionization.

11. **Correct Answer C.** 1 mol. of Mg on reaction releases 600 kJ, n(Mg) = 8000/600 = 13.33,

    m(Mg) = n x M = 13.33 x 24.3 = 324g.

12. **Correct Answer B.** The reactions that are occurring are:

    $Zn^{2+}_{(aq)} + 2e^- \rightarrow Zn_{(s)}$ is Reduction and $2H_2O_{(l)} \rightarrow O_{2(g)} + 4H+_{(aq)} + 4e^-$ is Oxidation

    Water is both a solvent and a reductant.

13. **Correct Answer D.** Air is a mixture that contains approximately 20% oxygen so using air would decrease the concentration of oxygen and so decreasing the number of particles available to react therefore decreasing the rate.

14. **Correct Answer A.** For the endothermic self-ionisation reaction, an increase in temperature will move the position of equilibrium to the right in an attempt to lower the temperature. The concentration of the hydronium ion will increase, and so the pH will decrease. At 30^0C the pH will be less than 7 (although the water is still neutral as the hydroxide concentration has also increased by the same amount).

15. **Correct Answer C.** Referring to the electrochemical series, $Cu^{2+,}$ Sn^2+ and Ni^{2+} are all stronger oxidants than water and will be preferentially reduced. H_2O is a stronger oxidant than K^+ and will be preferentially reduced.

16. **Correct Answer D.** All industrial processes should be minimising energy use during each stage of every process.

17. **Correct Answer D.** All 3 answers are correct.

18. **Correct Answer C.** The second equation is the reverse of the first equation and all the coefficients are doubled. Reversing an equation produces the reciprocal of the equilibrium constant of the first equation i.e. 1/K. Raising all the concentrations in the equilibrium expression to the power of two causes the equilibrium constant to be squared i.e. $(1/K)^2$ or $1/K^2$.

19. **Correct Answer B.** $Mg^{2+/}$Mg half- cell is the weaker oxidant or stronger reductant and so will undergo oxidation; so the $Mg^{2+/}$Mg half- cell is the anode and has a negative polarity in a galvanic cell.

20. **Correct Answer B.** K^+ ions migrate to the cathode. This is the Ag electrode in this case; here Ag^+ ions are converted to Ag so positive charge is lost. K^+ ions migrate to the cathode to balance the positive charges at that electrode.

SECTION B- Short answer questions

Question 1

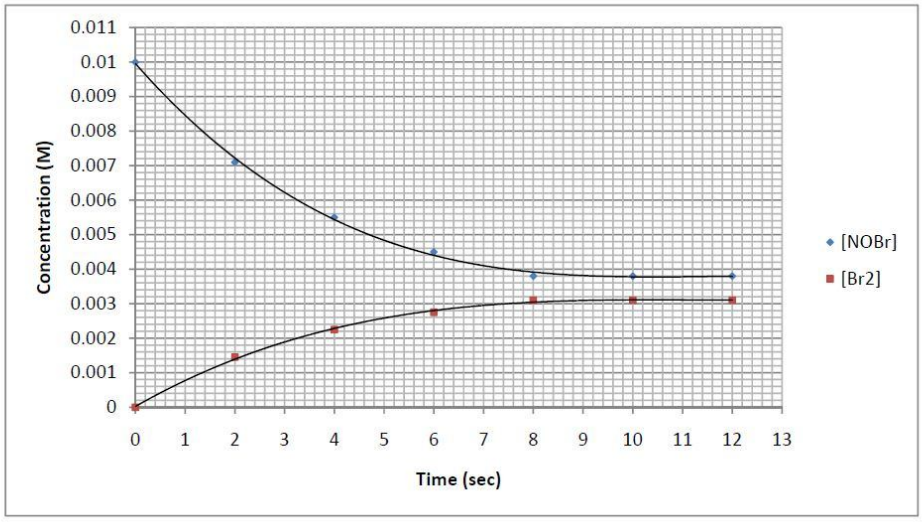
a) Initial Rate = Gradient (at the beginning) = rise/run = 0.0016/1 = -1.6×10^{-3} [NOBr]Ms^{-1} (1)

All rates are negative as the [NOBr] is decreasing.

b) Av. Rate over 8s = 0.0039-0.010/8-0 = -7.6×10^{-4} Ms^{-1} (1)

c) The initial rate > the rate over the first 8s since [reactants] is higher at the start. (½) As the reaction proceeds [reactants] ↓ leading to fewer successful collisions. (½)

d) Bromine formation graph below.



Time (s)	[NOBr]	$[Br_2]$
0	0.01	0
2	0.0071	0.00145
4	0.0055	0.00225
6	0.0045	0.00275
8	0.0038	0.0031
10	0.0038	0.0031
12	0.0038	0.0031

For every 2 mol of NOBr reacting only 1 mol of Br_2 forms. $[Br_2]\uparrow$ at half the rate [NOBr]$\downarrow$.

At t = 8s [NOBr] remains constant indicating that the reaction has come to completion. Here the $[Br_2]$ also remains constant.

$[Br_2]$ = ½Δ[NOBr] e.g. at 6s $[Br_2]$ = ½Δ[NOBr] = (0.01- 0.0042)½ = 0.00275M

e) As P$\uparrow$, V$\downarrow$ $\rightarrow$ an increase in the [reactants] (1). This leads to more successful collisions between two NOBr particles over a period of time and so the reaction rate increases.

f) In this reaction only one reactant decomposes to form products. How many particles having enough energy to overcome E_A and decompose is the crucial fact affecting the reaction rate. (1) $\downarrow$P has no effect on reaction rate. The number of moles reacting is equal to the number of moles produced.

$\uparrow$T would $\uparrow$ reaction rate by providing more particles with enough energy to overcome E_A (1)

Using a catalyst would $\uparrow$ reaction rate by providing an alternative pathway with $\downarrow E_A \rightarrow \uparrow$ no. of particles reacting.

Question 2

a) A weak acid undergoes partial ionisation to produce H_3O^+ ions. It ionises to a small extent (1)

b) HCOOH is a weak acid and therefore the $[HCOO^-]$ cannot be directly calculated from the [HCOOH]

K_a (HCOOH) $= 1.8 \times 10^{-4}$

$K_a = [H_3O^+][HCOO^-]/[HCOOH]$ (1)

$[HCOO^-] = [H_3O^+]$ (1)

$[HCOO^-]^2 = K_a[HCOOH] = 1.8 \times 10^{-4} \times 0.0500 = 9 \times 10^{-6}$ (1)

$[HCOO^-] = \sqrt{9 \times 10^{-6}} = 0.003M$ (1)

c) $HCOO^-_{(aq)} + H_2O_{(l)} \rightleftharpoons OH^-_{(aq)} + HCOOH_{(aq)}$ Equilibrium arrows must be included (1) along with reactants and products states (1)

d) $K_b = [OH^-][HCOOH]/[HCOO^-]$ (1)

Question 3

a) Positive electrode : $2Cl^-_{(aq)} \rightarrow Cl_{2(g)} + 2e^-$ (1)

Negative electrode; $H_20_{(l)} + 2e^- \rightarrow H_{2(g)} + 2OH^-_{(aq)}$ (1)

b) i) $2Cl^-_{(aq)} \rightarrow Cl_{2(g)} + 2e^-$

$n(NaCl) = n(Cl^-) = cV = 1.00 \times 10.00 = 10.0$ mol.

$n(Cl_2) = ½\, n(Cl^-) = ½ \times 10.0 = 5.00$ mol (1)

$n(Cl_2) = V/24.5$, so $V = 5.00 \times 24.5 = 122.5$ L $= 123$ L (1)

ii) $Q = n(e^-) \times F = 10.0 \times 96\,500 = 965{,}000$C (1)

$Q = It$, so $t = Q/I = 965{,}000/20 = 48250$ s (1), $t = 48250/3600 = 13.4$ hrs. (1)

c) Electrical energy → Chemical energy (1)

Question 4

a) 240V power supply: non-renewable, (1) 12V car battery: renewable(1)

b) Advantage: 240V power supply; inexpensive, (1) constant voltage (1), continuous supply under heavy load (1), widespread (1), a reliable source (1)

12V car battery: mobile (1), rechargeable (1), readily replaceable (1), commonly available (1)

Disadvantage: **240V power supply**: need for a connection to the electricity grid, (1), not available to cover remote areas (1), cost of hiring a powered site (1), can't use when mobile (1)

12V car battery: eventually goes flat with loss of power (1), under load the voltage decreases (1), eventually must be replaced (1), is only recharged when the car is mobile (1)

Question 5

a) $E = CF \times \Delta T = 1076 \times 5.84 = 6283.84\ J = 6.28 \times 10^3\ J$ (1)

b) $E = 6283.84/0.503g$ (1) $= 6283.84/0.01863$ mol $\quad n(Al) = 0.503/27 = 0.01863$ mol

$= 337.3\ kJ\ mol^{-1}$ (1), $\Delta H = 2 \times -337.3 = -675\ kJ\ mol^{-1}$ (1)

c) $n(Fe) = m/M = 0.651/55.9 = 0.0100$ mol (1)

2 mol $\rightarrow$828kJ

0.01 mol $\rightarrow$ x kJ, $x = -4.155$ kJ (1)

$\Delta T = E/CF = 4155/1076 = 3.86\ ^0C$ (1)

d) Iron (1) as the ΔH for the reverse reaction (the extraction of the metal from its ore) is higher than that of aluminium (1)

Question 6

a) $K_c = [Z]^2/[X]^2[Y]$ (1)

b) Concentration fraction $= 3^2/(2^2 \times (1) \neq 3$ so therefore the system is not at equilibrium (1)

c) An increase in V results in an overall decrease in concentration. In this system there would be a net back reaction to partially oppose the change (LCP) by creating more particles to increase the overall number (1). This causes the number of mole of Y to increase(1) but the overall concentration of Y decreases because of the initial dilution (1)

Question 7

Production of Sulphuric Acid (Contact Process)

a) $2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)}$ (1) ΔH is negative (1)

b) Use of Vanadium pentoxide as a catalyst in the converter-reduces activation energy and also quickens rate (energy efficiency) (1)

Any $S0_2$ not initially converted is recycled back into the catalytic converter to increase percentage yield (reaction mixture is passed over the catalyst beds several times). This reduces $S0_2$ emissions into the atmosphere.(1)

c) Strong Acid (1) $H_2SO_{4\,(l)} + H_2O_{(l)} \rightarrow H_3O^+_{(aq)} + HSO_4^-{}_{(aq)}$ (1)

Production of fertiliser (1) $H_2SO_{4\,(l)} + 2NH_{3(g)} \rightarrow (NH_4)_2SO4_{(aq)}$ (1)

Production of Ammonia (Haber-Bosch Synthesis)

a) $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$ (1) ΔH is negative (1)

b) Use of an Fe catalyst with K, Ca and Al promoters to reduce activation energy (1)

A reaction temperature of 450^0C is a compromise between yield and rate. A higher temperature will increase the yield and the rate but will require more energy (1)

c) Production of fertilisers (1) $NH_{3(g)} + HNO_{3(aq)} \rightarrow NH_4NO_{3(aq)}$ (1) or

$2NH_{3(g)} + H_2SO_{4(aq)} \rightarrow (NH_4)_2SO_{4(aq)}$ (1)

The oxidation of Ammonia in the first step of the production of Nitric Acid (1)

$4NH_{3(g)} + 5O_{2(aq)} \rightleftharpoons 4NO_{(g)} + 6H_2O_{(g)}$ ΔH is negative (1)

Production of Nitric Acid (Ostwald Process)

a) The process involves 3 steps:

i) The oxidation of Ammonia $4NH_{3(g)} + 5O_{2(aq)} \rightleftharpoons 4NO_{(g)} + 6H_2O_{(g)}$ (1)
ΔH is negative (1)

ii) The oxidation of nitric oxide $2NO_{(g)} + O_{2(g)} \rightleftharpoons 2NO_{2(g)}$ ΔH is negative (1)

iii) The hydrolysis of nitrogen oxide

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b) In step 1 the control of the production of NO is achieved by using a fine-wire gauze catalyst of an alloy of Platinum (90%) and Rhodium (10%) and suitable reaction conditions. The contact time with the catalyst is crucial, less than 0.003s, or the NO would decompose to N_2. This reaction is one of the most efficient catalytic reactions known with a percentage yield of approx. 96% (1)

The heat produced in this step is recovered and is enough to supply most of the energy demands of the process providing huge savings, e.g. boiling water to produce steam to turn a turbine to produce electricity(1)

c) Production of Fertilisers (1) $NH_{3(g)} + HNO_{3(aq)} \rightarrow NH_4NO_{3(aq)}$ (1)

A strong oxidant (1) $Cu_{(s)} + 4HNO_{3(aq)} \rightarrow Cu(NO_3)_{(aq)} + 2NO_{2(g)} + 2H_2O_{(l)}$ (1)

