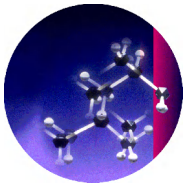


CHEMOLOGY EDUCATION SERVICES

Name:_____

Victorian Certificate of Education
2008 CHEMISTRY Unit 4
TRIAL EXAM

Time allowed: 1 hour 30 minutes

QUESTION AND ANSWER BOOKLET

Structure of booklet

Section	Number of questions	Number of questions to be answered
A	20 multiple choice questions	20 multiple choice questions
B	8	8

Directions to students

Materials
Question and answer booklet of 20 pages.
Answer sheet for multiple choice questions.
An approved calculator may be used.

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 73 marks available.
All answers should be written in English.

P O BOX 477 MENTONE 3194
Telephone/Fax 9587 2839 or 0412 405 403

SECTION A

Specific instructions for Section A

Question 1 consists of 20 multiple choice questions. Section A is worth approximately 27% of the marks available. You should spend about 30 minutes on this section.

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

Consider the following reaction:

$$CH_3COOH(aq) + NaHCO_3(s) \rightarrow NaCH_3COO(aq) + CO_2(g) + H_2O(l)$$

Which of the following properties could best be used to measure the reaction rate?

A. the volume of CO_2
B. the volume of H_2O
C. the mass of CH_3COOH
D. the surface area of $NaHCO_3$

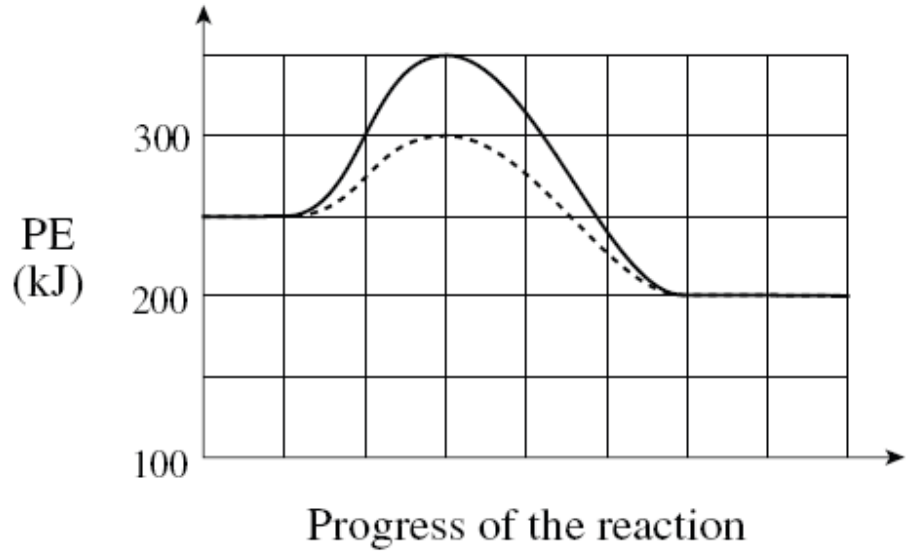
Question 2

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

Consider the following PE diagram:



Question 3
Which of the following is true for the **reverse reaction**?

		ΔH	E_a
A.	catalyzed	−50 kJ	100 kJ
B.	catalyzed	+50 kJ	150 kJ
C.	uncatalyzed	−50 kJ	100 kJ
D.	uncatalyzed	+50 kJ	150 kJ

Question 4
Consider the following equilibrium system:

$$2NO(g) + O_2(g) \quad \leftrightarrow \quad 2NO_2(g)$$

An equilibrium mixture of NO(g), O_2 (g) and NO_2 (g) is transferred from a 1.0 L container to a 2.0 L container. Which reaction is favoured and what happens to the $[NO_2]$?

	Reaction Favoured	$[NO_2]$
A.	reverse	increases
B.	reverse	decreases
C.	forward	increases
D.	forward	decreases

Question 5
Methanol CH_3OH is produced according to the following equilibrium equation:

$$CO(g) + 2H_2(g) \quad \leftrightarrow \quad CH_3OH(g) \quad + \text{energy}$$

Which conditions would favour a high yield of methanol?

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

Question 6
Which of the following is a renewable resource?

A. Ethanol
B. Uranium
C. Petroleum
D. Aluminium

Question 7
Consider the following equilibrium equation:

$$H_2\,(g) + C_2N_2\,(g) \leftrightarrow 2HCN(g) \qquad K_{eq} = 1.20$$

Initially, 0.86mol H_2 , 2.8mol C_2N_2 and 1.6mol HCN are placed in a 2.0L flask.
Which of the following is true?

A. Trial K*eq* > K*eq* so the reaction proceeds to the left.
B. Trial K*eq* < K*eq* so the reaction proceeds to the left.
C. Trial K*eq* < K*eq* so the reaction proceeds to the right.
D. Trial K*eq* > K*eq* so the reaction proceeds to the right.

Question 8
What is the pH of a 2.5M KOH solution?

A. -0.40
B. 0.40
C. 13.60
D. 14.40

Question 9
One of the species in the chemical indicator HIn^- exhibits a yellow colour. If acid is added, the indicator turns red. Which of the following is correct?

	Red	Yellow
A.	In^{2-}	H_2In
B.	In^{2-}	HIn^-
C.	HIn^-	H_2In
D.	H_2In	HIn^-

Question 10
How does the oxidation number change for O if Na_2O_2 is converted to Na and O_2 ?

A. decreases by 1
B. no change
C. increases by 1
D. increases by 2

Use the following half-reactions to answer questions 11 and 12.

1	$2H_2SO_3 + 2H^+ + 4e^- \rightarrow S_2O_3^{2-} + 3H_2O$
2	$SnCl_6^{2-} + 2e^- \rightarrow Sn^{2+} + 6Cl^-$
3	$\frac{1}{2}Hg_2^{2+} + e^- \rightarrow Hg(\ell)$
4	$Sb_2O_5 + 6H^+ + 4e^- \rightarrow 2Sb(OH)_2^+ + H_2O$

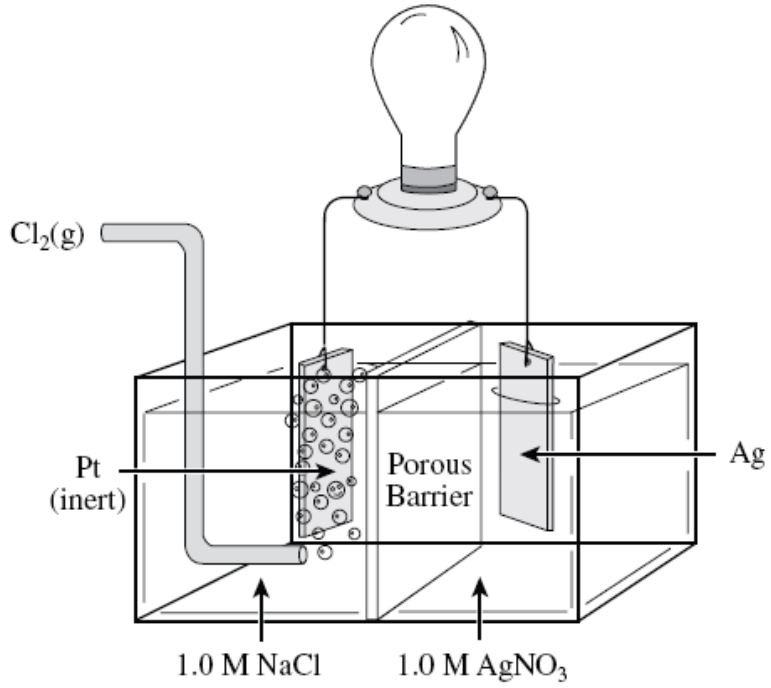
Question 11
A redox reaction occurs when Sb_2O_5 is mixed with $S_2O_3^{2-}$, but no reaction occurs when Sb_2O_5 is mixed with Hg. A solution of $SnCl_6^{2-}$ has no effect on $S_2O_3^{2-}$. Which of the following describes the order of the half-reaction reduction potentials from highest to lowest?

A. 2 > 1 > 4 > 3
B. 2 > 4 > 1 > 3
C. 3 > 1 > 4 > 2
D. 3 > 4 > 1 > 2

Question 12
The initial voltage of a standard electrochemical cell based on the half-reactions 3 and 4 above, is 0.22V. If Hg_2^{2+} is reduced and its E^0 is +0.80 volts, what is the reduction potential for half-reaction 4?

A. -0.58 V
B. +0.58V
C. +0.63V
D. +1.02V

Use the following diagram to answer questions 13 and 14.



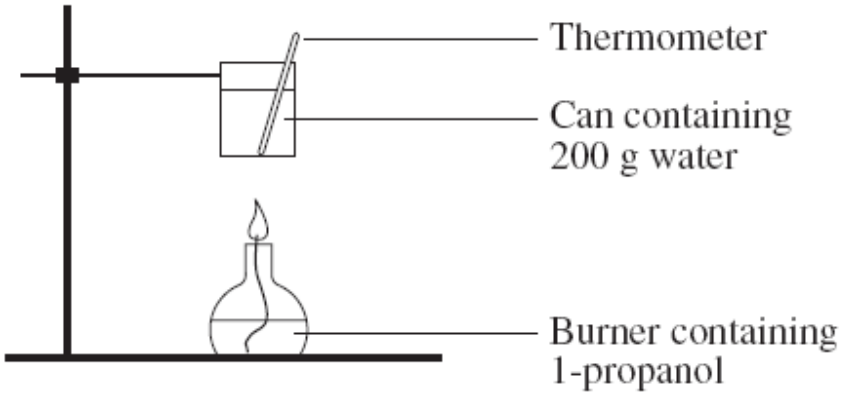
Question 13
Which of the following gives the anode material and its correct half-reaction?

	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 14
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 15
A student used the apparatus below to determine the molar heat of combustion of propanol, C_3H_7OH.



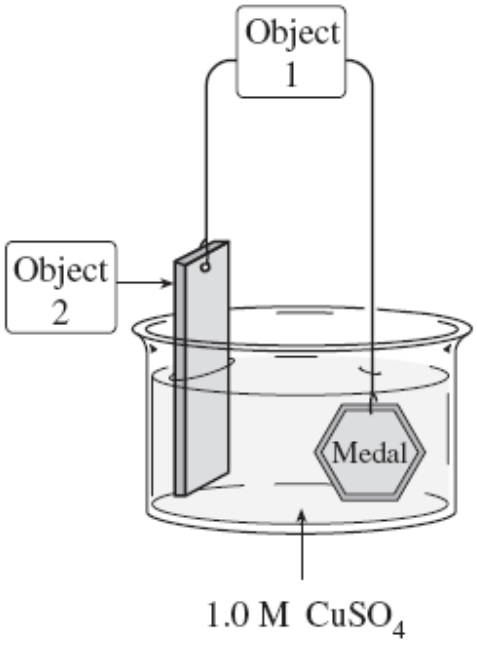
The following results were obtained:

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 16
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

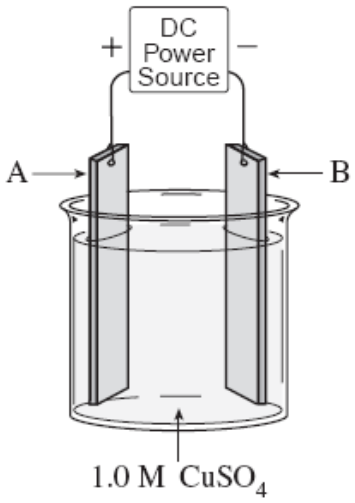
A. 0.25M
B. 0.50M
C. 0.75M
D. 1.0M

Question 17
Which pair of factors both affect the amount (in mol) of chlorine produced in the electrolysis of aqueous sodium chloride?

A. current and temperature
B. temperature and chloride ion concentration
C. chloride ion concentration and length of time of electrolysis
D. pressure and length of time of electrolysis

Question 18
Which of the following occurs during the electrolysis of molten KCl?
A. Oxygen forms at the anode.
B. Potassium forms at the anode.
C. Chlorine forms at the cathode.
D. Potassium forms at the cathode.

Use the following diagram to answer questions 19 and 20.



Question 19
The above cell is constructed in order to copper plate an object.
For best results, which of the following should be used for electrodes A and B?

	Electrode A	Electrode B
A.	object	pure copper
B.	pure copper	object
C.	object	any conductor
D.	any conductor	object

Question 20
A student tries to use the above apparatus to copper plate a zinc object. What will happen if the student places the zinc object at A and the copper electrode at B?

	Electrode A	Electrode B
A.	$Cu_{(s)}$ forms	Cu dissolves
B.	Zn dissolves	$Zn_{(s)}$ forms
C.	Zn dissolves	$Cu_{(s)}$ forms
D.	Bubbles form	Bubbles form

END OF SECTION A

SECTION B

Specific Instructions for Section B

Section B consists of 8 short answer questions (question 1 to 8). You must answer all of these questions. The section is worth 53 marks or approximately 73% of the total. You should spend approximately 60 minutes on this section. The marks allocated and suggested times are at the end of each question.
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 (4 marks)

The dissolving of calcium chloride in water is represented by:

$$\mathbf{CaCl_2\,(s) \rightarrow Ca^{2+}\,(aq) + 2Cl^-\,(aq) \quad \Delta H = -75.6\ kJ\ mol^{-1}}$$

(a) (i) Explain what ΔH represents. (1 mark)

_____

_____

_____

(ii) State whether this is an exothermic or endothermic reaction. (1 mark)

_____

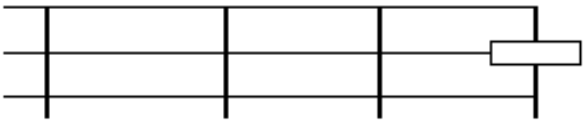
(b) If 50.0 g of calcium chloride were dissolved in excess water what would be the energy change resulting from the reaction? (2 marks)

_____

_____

_____

Question 2 (8 marks)
A farm fence is made of wooden posts with three strands of galvanised wire between the posts. The corner post has a steel sign nailed to it.



(a) After a particularly wet winter the sign fell off because the iron nails had rusted. Explain why the iron nails had more rust on the part that had been inside the post. Include relevant equations and a diagram. (3 marks)

(b) The farmer repaired the fence and replaced the steel sign using copper nails thinking that they would not corrode in the post. However, the sign fell off again a few months later. Explain why. (3 marks)

(c) The next summer the fence was burned in a bush fire. Explain why the wire strands rusted very quickly after the fire. (2 marks)

Question 3 (8 marks)
A typical Hall-Heroult cell used for the electrolytic extraction of aluminium from alumina, Al_2O_3, operates at 5.00 volts with a current of 150 000 amperes.

(a) Write the half equation for the reduction of the aluminium ion in the alumina. (1 mark)

_____

(b) Determine the mass of aluminium produced by such a cell over a 24-hour period. (3 marks)

_____

_____

_____

_____

_____

Calcium is produced by the electrolysis of molten calcium chloride, $CaCl_2$, using inert electrodes.

(c) Write an equation showing the products at: (2 marks)

(i) the anode:

_____

(ii) the cathode:

_____

(d) If a solution of calcium chloride were electrolysed with inert electrodes, indicate (using an equation) the products expected at each electrode. (2 marks)

(i) the anode:

_____

(ii) the cathode:

_____

Question 4 (4 marks)
The reaction between calcium and water is represented by:

$$\mathbf{Ca\ (s) \quad + \quad 2\ H_2O\ (l) \quad \rightarrow \quad Ca(OH)_2\ (s) \quad + \quad H_2\ (g)}$$

A student conducts an experiment and has three beakers containing the following:

- **Beaker A**: 2.00 g lump of calcium, 2.00 L of water at 15°C temperature;
- **Beaker B:** 2.00 g lump of calcium, 2.00 L of water at 25°C temperature;
- **Beaker C:** 2.00 g of small calcium pieces, 2.00 L of water at 25°C temperature.

(a) Which beaker will have the fastest reaction rate? (1 mark)

_____

(b) Give reasons in terms of Collision Theory for your answer in (a). (3 marks)

_____

_____

_____

_____

_____

Question 5 (6 marks)
You have studied the production of one of the following industrial chemicals in this unit:

ammonia, ethene, sulfuric acid or nitric acid.

a) Equilibrium principals are involved in the prodcution of each of these chemicals. Chose one from the list above and write an equilibrium equation that occurs during its production. Include whether the reaction is exothermic or endothermic. (2 marks)

_____

b) Explain with reference to the chosen equation how factors affecting rate and equilibrium are applied to achieve optimum conditions for the reaction to proceed. (4 marks)

_____
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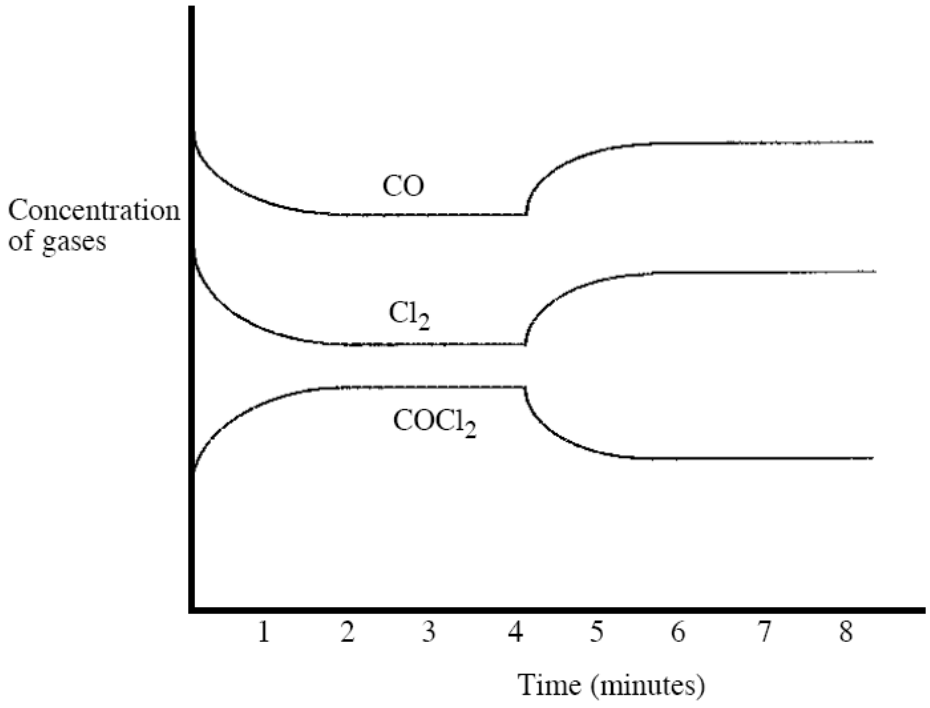
Question 6 (8 marks)
Phosgene gas, $COCl_2$, is prepared according to the following reversible reaction:

$$\mathbf{CO\ (g)\ +\ Cl_2\ (g)\ \leftrightarrow\ COCl_2\ (g)}$$

A mixture containing these three gases is introduced into a closed system in the presence of a charcoal catalyst. The following graph shows how the concentration of these gases varies with time.



(a) Describe the system three minutes after mixing. (1 mark)

_____

_____

(b) Four minutes after mixing, the temperature was increased by 25°C. From the system's response shown on the graph above, deduce whether the reaction as written is endothermic or exothermic. Explain. (2 marks)

_____

_____

_____

_____

Question 6 continued

(c) Write an expression for the equilibrium constant of this reaction. (1 mark)

(d) 0.100 mole of $COCl_2$*(g)* is put into a 2.00 L closed vessel and allowed to come to equilibrium at 25°C. When equilibrium was reached the $COCl_2$*(g)* concentration is measured as 0.0447M. Calculate the equilibrium constant at a temperature of 25°C. (4 marks)

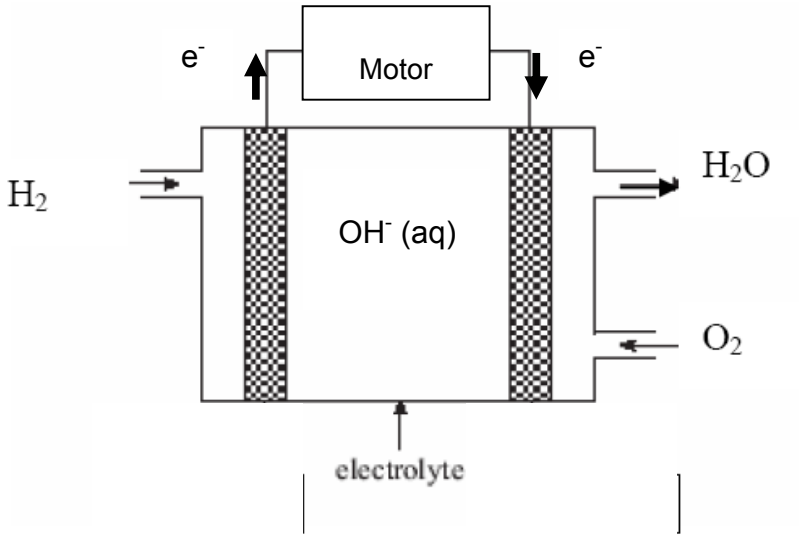
Question 7 (6 marks)

(a) Determine the pH of a 0.0155M aqueous solution of the strong base barium hydroxide, $Ba(OH)_2$. (2 marks)

(b) The Ka for ethanoic acid, CH_3COOH, is 1.80×10^{-5}. Calculate the pH of a 0.150M aqueous solution of ethanoic acid. (4 marks)

Question 8 (9 marks)

Car makers are quite well advanced in the development of fuel cells for cars using hydrogen gas as the main fuel. A simplified diagram is shown below:



The fuel cell consists of two sections: hydrogen gas is pumped through one half and oxygen gas the other. The two halves are joined and an alkaline electrolyte such as KOH passes through the middle. The electrodes consist of a porous nickel alloy mesh.

a) Write balanced ionic half equations for the reactions occurring at the anode and cathode. (2 marks)

Anode _____

Cathode_____

b) i) State **two** roles of the nickel electrodes. (2 marks)

_____

_____

Question 8 continued

ii) Given that the cost of building an engine to run on hydrogen is significantly greater than petrol engines, give **two** advantages of using these cells over petrol engines. (2 marks)

_____

_____

_____

_____

c) A particular fuel cell generated 7.82 A for 2.00 hours. Calculate the volume of hydroegn gas required at a pressure of 3000 kPa and a temperature of 200^0C during this time. (3 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

	$E^\ominus$ 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

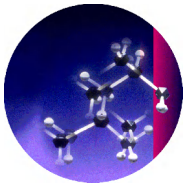
1 H 1.0																	2 He 4.0
3 Li 6.9	4 Be 9.0											5 B 10.8	6 C 12.0	7 N 14.0	8 O 16.0	9 F 19.0	10 Ne 20.1
11 Na 23.0	12 Mg 24.3											13 Al 27.0	14 Si 28.1	15 P 31.0	16 S 32.1	17 Cl 35.5	18 Ar 39.9
19 K 39.1	20 Ca 40.1	21 Sc 44.9	22 Ti 47.9	23 V 50.9	24 Cr 52.0	25 Mn 54.9	26 Fe 55.9	27 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)



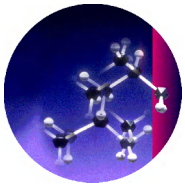
CHEMOLOGY EDUCATION SERVICES

Name:_____

CHEMISTRY EXAM 2
MULTIPLE CHOICE ANSWER SHEET

Colour the box after the letter corresponding to your answer.

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☐



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SUGGESTED SOLUTIONS TO 2008 CHEMISTRY TRIAL EXAM 2

Section A

1 D		**11 D**	If a reaction procedes the oxidant must be higher on the table than the reductant. 1st reaction 4 > 1 2nd reaction 3 > 4 3rd reaction 1 > 2
2 B		**12 B**	EMF = E^0(oxidant) - E^0(reductant) 0.22 = 0.80 – A A = +0.58 volts
3 D	ΔH = H (products – reactants) = 250 – 200 = 50 Exothermic Ea uncatalysed = 350 – 200 = 150	**13 C**	Silver is a stronger reducatant than Cl^-
4 B	Volume increase = pressure decrease favours side with greater number of particles. Backwards. [NO_2] decreases as volume has increased.	**14 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.
5 B	High yield favoured by Temp. decrease as reaction is exothermic and pressure increase as smaller number of particles occurs on the products side.	**15 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
6 A		**16 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
7 A	[HCN]^2 / [H_2] x [C_2N_2] = (1.6/2)^2/(0.86/2) x (2.8/2) = 2.47 Trial Keq > Keq Trial Keq needs to be less, reaction needs to move backwards.	**17 C**	
8 D	[H^+] = 10^{-14}/2.5 pH = -log (10^{-14}/2.5) = 14.4	**18 D**	
9 D	Hin^- (yellow) will gain H^+ to become H_2In (red)	**19 B**	Object to be plated is placed at cathode in electrolysis cell where reduction of metal ion occurs, Cu^{2+} + 2e → Cu.
10 C	Na_2O_2 → O_2 Ox. No. 2 x (+1) + (-2) =0 0 Each O = -1 Oxygen changes from -1 → 0 increases by 1	**20 C**	Zinc will oxide at at anode as it is the strongest oxidant in contact with anode. Copper will still form as Cu^{2+} is still the strongest oxidant present. Cu^{2+} > Zn^{2+} .

Section B ❶ = 1 mark

Question 1
(a) (i) ΔH is the enthalpy difference between reactants and products.
Specifically H(products) –H(reactants) ❶

(ii) exothermic ❶

(b) n($CaCl_2$) = 50.0 / 111.1 = 0.45mol ❶ Energy = 0.45 x 75.6 = **34.0 kJ** ❶

Question 2
(a) Requires some explanation about the corrosion process occurring on the iron nails due to the differing concentrations of available oxygen with reduction occurring at higher concentrations of oxygen and oxidation occurring at lower concentrations of oxygen. ❶This is the reason for the 'pitting' of the nails inside the wood.

$Fe\ (s) \rightarrow Fe^{2+}\ (aq) + 2e$ ❶

$O_2\ (g) + 2H_2O\ (l) + 4e \rightarrow 4OH^-\ (aq)$ ❶

(b) This question is about the corrosion of the steel signs that were attached to the copper nails.
You need to talk about the electrochemical process that occurs when two metals are in contact.❶
Correctly saying that reduction occurred on the copper nails giving the reduction half equation as $Cu^{2+} + 2e \rightarrow Cu$ ❶

Steel being made of iron will oxidise in preference to copper.
Anode reaction: $Fe\ (s) \rightarrow Fe^{2+}\ (aq) + 2e$❶

(c) You need to mention that the galvanised coating on the wires was in some way damaged or removed by the fire and consequently the exposed iron strands were able to undergo the usual corrosion process after the fire.

Question 3
a) $Al^{3+}\ (l) + 3e \rightarrow Al(l)$ ❶

b) $m = \frac{150000 \times 24 \times 60 \times 60 \times 1 \times 27}{96500 \times 3} = 1208kg$ ❶❶❶

c) i) Anode $2\ Cl^-\ (l) \rightarrow Cl_2\ (g) + 2e$ ❶

ii) Cathode $Ca^{2+}\ (l) + 2e \rightarrow Ca(l)$ ❶ be careful with states **molten** $CaCl_2$
d) give credit for choosing either chlorine gas or oxygen gas as a predicted product as both are possible at anode especially as the concentration of the solution was not mentioned in the question.
i) Anode $2H_2O\ (l) \rightarrow O_2(g) + 4H^+\ (aq) + 4e$ ❶

ii) Cathode $2H_2O$ (l) + 2e → H_2 (g) + 2 OH^- (aq) ❶

Question 4

a) Beaker C as it has the largest surface area of particles at the higher temperature.

b) A larger surface area will have a larger area of contact❶ and result in more fruitful collisions between particles. The higher temperature will result in the particles moving more quickly ❶and will have more energy to be able to overcome the activation energy barrier.❶

Question 5

a) For ammonia N_2 (g) + $3H_2$(g) ↔ $2NH_3$ (g) ΔH –ve ❶❶

Ethene C_7H_{16}(g) ↔ C_2H_4 (g) + C_5H_{12} (g) ΔH +ve

Sulfuric acid $2SO_2$ (g) + O_2 (g) ↔ $2SO_3$(g) ΔH -ve

Nitric acid $4NH_{3(g)} + 5O_{2(g)} \leftrightarrow 4NO_{(g)} + 6H_2O_{(g)}$ ΔH –ve

A discussion of how pressure, temperature and concentration will lead to a maximum yield. For example with ammonia
A high yield will result from a high pressure and low temperature. However, a low temperature will result in a slow rate so a moderate temperature is used with a catalyst to speed up the rate.
A maximum of ❶❶❶❶marks for making correct statements.

Question 6

a) System at equilibrium ❶

b) Exothermic. ❶ As the temperature was increased the reaction moved backwards.❶

c) $[COCl_2] / [CO] \times [Cl_2]$ ❶

d)

Reaction moves ←

	CO	Cl_2	$COCl_2$
n(initially)	0	0	0.1
n (reacts)	0.0106mol	0.0106mol	0.1 – 0.0894 = 0.0106mol ❶
n(At equilibrium)	0.0106mol	0.0106mol	n = CV = 0.0447 x 2 =0.0894mol ❶
Concentration at equilibrium	0.0106mol / 2.0 = 0.0053	0.0106mol / 2.0 = 0.0053 ❶	0.0447

$$K = \frac{0.0447}{(0.0053)^2} = \mathbf{1591\ M^{-1}}$$ ❶

Question 7

a) $[OH^-] = 2 \times 0.0155 = 0.031$ ❶
$[H^+] = 10^{-14} / 0.031$

pH = $-\log (10^{-14} / 0.031)$ = **12.5** ❶

b) $K_a = \frac{[CH_3COO^-][H^+]}{[CH_3COOH]}$ ❶

$1.80 \times 10^{-5} = \frac{[H^+]^2}{0.150}$ ❶

$[H^+] = 0.00164$ M ❶

pH = -log0.00164 = **2.79** ❶

Question 8

a) Anode $H_2(g) + 2OH^-(aq) \rightarrow 2H_2O(l) + 2e$ ❶

Cathode $O_2(g) + 2H_2O(l) + 4e \rightarrow 4OH^-(aq)$ ❶

b) i) Conduct electricity / catalyst/ allow gases to mix / site of oxidation and reduction ❶❶

ii) Any two of:

- Fuel cells are highly efficient in converting chemical energy directly to electrical energy (about 60%). Petrol engines are much less about 25 – 30%
- The product of cell is water. Preferable to polluatnts from petrl engines.
- The reactants, hydrogen and oxygen, can be produced from water and so are renewable sources, unlike petrol ❶❶

c) $n(e) = \frac{7.82 \times 2.00 \times 60 \times 60}{96500} = 0.583$ mol ❶❶

$n(H_2) = ½\ n(e) = 0.292$ mol ❶

$v(H_2) = \frac{0.292 \times 8.31 \times 473}{3000}$ ❶
= 0.382 L or 382 ml ❶

