

CHEMOLOGY EDUCATION SERVICES

Name: _____

Victorian Certificate of Education 2009 CHEMISTRY Unit 4 TRIAL EXAM

Time allowed: 1 hour 30 minutes

QUESTION AND ANSWER BOOKLET

Structure of booklet

<u>Section</u>	<u>Number of questions</u>	<u>Number of questions to be answered</u>
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.

Data Pages may be found at

http://www.vcaa.vic.edu.au/vce/studies/chemistry/chem1_sample_2008.pdf

The Task

Please 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 75 marks available.

All answers should be written in English.

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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

When a catalyst is added to a system at equilibrium, which of the following will decrease?

- A. Heat of reaction
- B. Activation energy
- C. Potential energy of the reactants
- D. Potential energy of the products

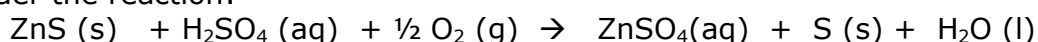
Question 2

What is the effect of adding a catalyst to an equilibrium system?

- A. The value of E_a increases.
- B. The value of K increases.
- C. Forward and reverse rates increase.
- D. The concentration of products increases.

Question 3

Consider the reaction:



What would increase the fraction of successful collisions?

I	increasing temperature
II	increasing surface area of ZnS
III	increasing $[\text{H}_2\text{SO}_4]$
IV	adding a suitable catalyst

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

Question 4

An uncatalyzed reaction has the following values for E_a :

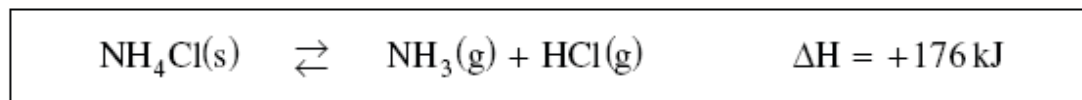
$$E_a(\text{forward}) = 250 \text{ kJ}$$

$$E_a(\text{reverse}) = 100 \text{ kJ}$$

If a catalyst is added to the reaction, which of the following values could be correct?

	$E_{a(\text{forward})} \text{ (kJ)}$	$E_{a(\text{reverse})} \text{ (kJ)}$	$\Delta H_{(\text{forward})} \text{ (kJ)}$
A.	50	200	-150
B.	50	200	+150
C.	200	50	-150
D.	200	50	+150

Use the following equilibrium to answer questions 5 to 7.

**Question 5**

Which of the following would cause a shift to the right?

- A. adding NH_4Cl
- B. removing NH_3
- C. increasing pressure
- D. decreasing temperature

Question 6

When HCl is added, how do the concentrations of NH_3 and HCl at the new equilibrium compare to the original equilibrium concentrations?

	$[\text{NH}_3]$	$[\text{HCl}]$
A.	higher	higher
B.	higher	lower
C.	lower	higher
D.	lower	lower

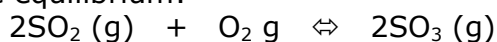
Question 7

Solid NH_4Cl is added to the preceding equilibrium. What will happen to the forward and reverse rates?

	Forward Rate	Reverse Rate
A.	increases	increases
B.	no change	no change
C.	increases	decreases
D.	decreases	increases

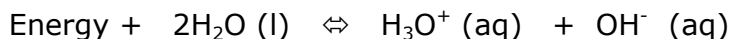
Question 8

Consider the equilibrium:



Initially, 1.6 mol SO_3 is placed in a 3.0 L container. At equilibrium, $[\text{O}_2] = 0.15\text{M}$. What is the value of K_{eq} ?

- A. 0.26
- B. 1.2
- C. 4.0
- D. 43

Question 9

Which of the following is correct for water?

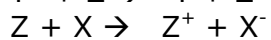
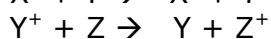
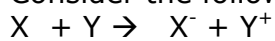
	Temperature	pH	Solution Type
A.	increases	increases	neutral
B.	increases	decreases	acidic
C.	increases	decreases	neutral
D.	decreases	increases	basic

Question 10

20 mL of 0.08 M HCl is mixed with 30 mL of 0.05 M NaOH.
What is the pH of the resultant solution?

- A 1.1
- B 2.7
- C 4.0
- D 7.0

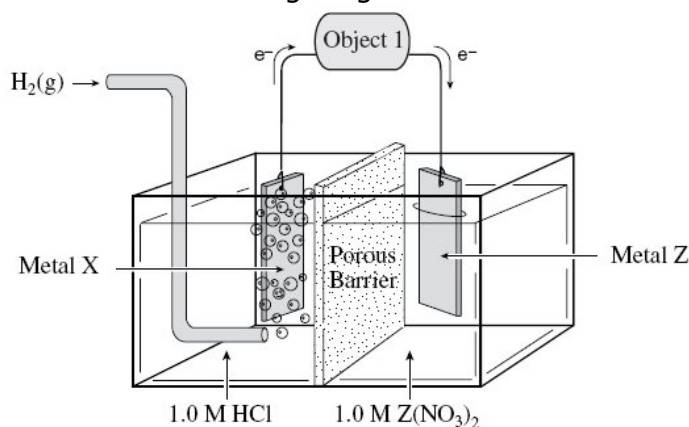
Consider the following spontaneous redox equations:

**Question 11**

Which of the following describes the relative strengths of the oxidizing agents?

- A. $Z > Y > X^-$
- B. $X^- > Y > Z$
- C. $X > Y^+ > Z^+$
- D. $Z^+ > Y^+ > X$

Consider the following diagram of a standard electrochemical cell:

**Question 12**

Which of the following is correct as the cell operates?

	Object 1	Metal X
A.	voltmeter	anode
B.	voltmeter	cathode
C.	power supply	anode
D.	power supply	cathode

Question 13

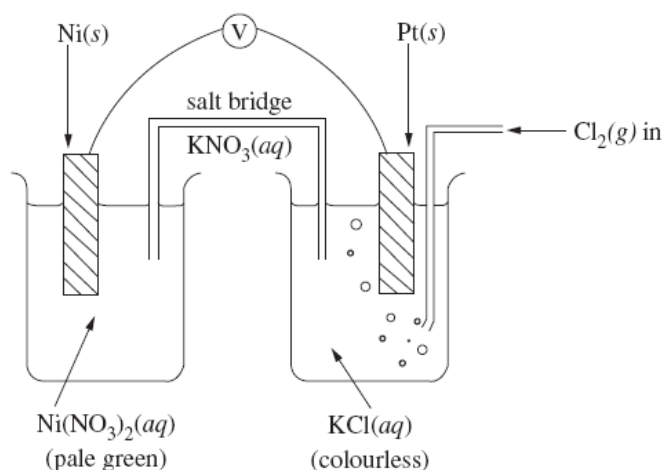
The electrolysis of aqueous Rb_2SO_4 solution using carbon electrodes produces changes in the solution around the electrodes. How will the pH change around the anode and the cathode?

	pH around the Anode	pH around the Cathode
A.	increase	increase
B.	decrease	decrease
C.	increase	decrease
D.	decrease	increase

Question 14

The same amount of electricity (same number of moles of electrons) is used to carry out the electrolysis of $\text{PdCl}_2(\text{aq})$ and $\text{AgNO}_3(\text{aq})$ solutions in separate cells. The masses of Pd and Ag produced were measured and compared. Which of the following is true about the mass of produced?

- A. The mass of Pd produced is not related to the mass of Ag.
- B. The mass of Pd produced is approximately half that of Ag.
- C. The mass of Pd produced is approximately twice that of Ag.
- D. The mass of Pd produced is approximately the same as that of Ag.

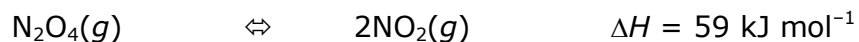
Question 15

In reference to the cell described above,

- A. $\text{Ni}_{(\text{s})}$ is oxidised at the anode and $\text{Cl}_{2(\text{g})}$ is reduced at the cathode.
- B. $\text{Ni}^{2+}_{(\text{aq})}$ ions are reduced at the cathode and $\text{Cl}_{2(\text{g})}$ is oxidised at the anode.
- C. Electrons travel from the Pt electrode to the Ni electrode.
- D. The Ni electrode is positive and the Pt electrode is negative.

Question 16

An experiment is carried out to investigate the effect of temperature change on the reaction represented by the equation:



What will result if the temperature increases?

- A The value of the equilibrium constant will remain the same, but equilibrium will be reached more quickly.
- B The value of the equilibrium constant will remain the same, but equilibrium will be reached more slowly.
- C The value of the equilibrium constant will increase.
- D The value of the equilibrium constant will decrease.

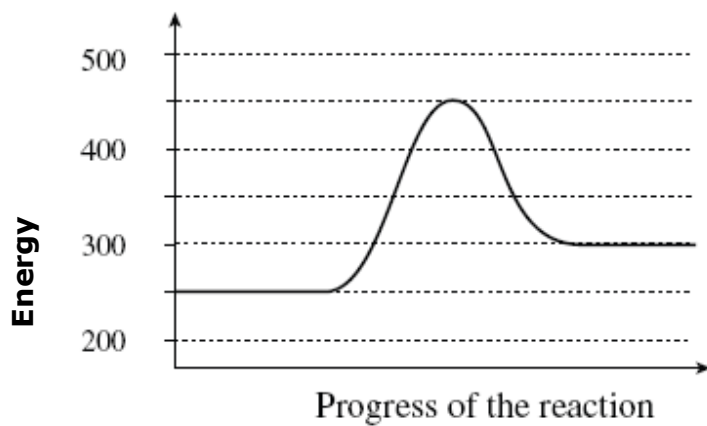
Question 17

What products result from the electrolysis of molten KBr ?

	Product at the Cathode	Product at the Anode
A.	K	O ₂
B.	K	Br ₂
C.	O ₂	H ₂
D.	Br ₂	K

Question 18

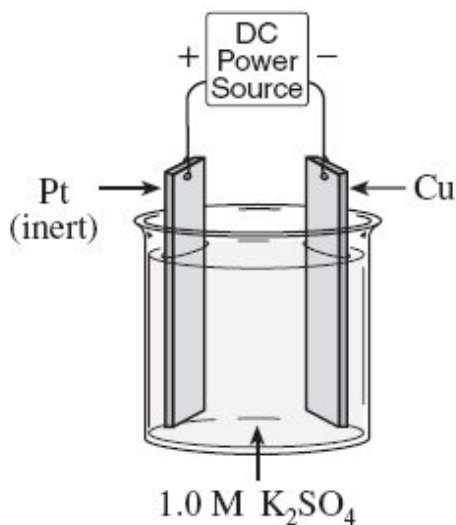
Consider the following Energy Profile diagram for a reversible reaction:



Which of the following correctly corresponds to the diagram above?

	E_a (forward) kJ	E_a (reverse) kJ	ΔH (forward) kJ
A	150	200	+50
B	200	150	+50
C	200	150	-50
D	450	300	+50

Use the following diagram to answer questions 19 and 20.



Question 19

What is the equation for the anode reaction?

- A. $\text{K} \rightarrow \text{K}^+ + \text{e}^-$
- B. $\text{Cu} \rightarrow \text{Cu}^{2+} + 2\text{e}^-$
- C. $2\text{SO}_4^{2-} \rightarrow \text{S}_2\text{O}_8^{2-} + 2\text{e}^-$
- D. $2\text{H}_2\text{O} \rightarrow \text{O}_2 + 4\text{H}^+ + 2\text{e}^-$

Question 20

Which of the following best describes the mass of the copper electrode and the direction of cation movement as the cell operates?

	Mass of the copper electrode	Cation movement
A.	increases	to the left
B.	stays the same	to the left
C.	stays the same	to the right
D.	decreases	to the right

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 55 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 $\text{H}_2(\text{g})$, $\text{NaCl}(\text{s})$.

Question 1 (6 marks)

The table shows four fuels and their various properties.

<i>Property</i>	<i>Petrol</i>	<i>Kerosene</i>	<i>Hydrogen</i>	<i>Ethanol</i>
Heat of combustion (kJ mol^{-1})	5460	10 000	285	1370
Boiling point ($^{\circ}\text{C}$)	126	300	-253	78
Density (g mL^{-1})	0.69	0.78	n/a	0.78
Average molar mass (g mol^{-1})	114	210	2	46

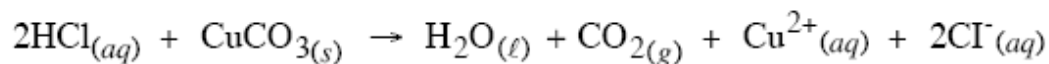
(a) Which fuel provides the greatest amount of energy per gram? (1 mark)

(b) A car has an 80 L petrol tank. Calculate the energy released by the complete combustion of one full tank of petrol. (3 marks)

(c) How many litres of hydrogen gas at 25°C and 100 kPa would be needed to supply the same amount of energy as 80 L of petrol? (2 marks)

Question 2 (7 marks)

Joan and Rebecca were investigating the rate of the reaction between copper carbonate and hydrochloric acid at a temperature of 4°C. They worked in a constant temperature room set at 4°C and added 0.500 mole of solid crushed blue-green copper carbonate, CuCO_3 , to 1.50 L of a 0.100M solution of hydrochloric acid, HCl in an open flask.



(a) Explain why it was necessary to use an open flask. (1 mark)

(b) Explain how and why changing the concentration of the hydrochloric acid and the particle size of the crushed solid could affect the rate of the reaction. (3 marks)

(c) The next day they repeated the experiment in the school laboratory using the same crushed copper carbonate and the same acid. They found that the rate had increased. Explain this discrepancy in terms of collision theory. (3 marks)

Question 3 (4 marks)

A platinum catalyst has become 'poisoned' with a deposit of tin. In an attempt to regenerate the platinum the tin is converted to Sn^{4+} by electrolysis.

What mass of tin would be removed after 5.00 hours, if the effective current was 0.20 A?

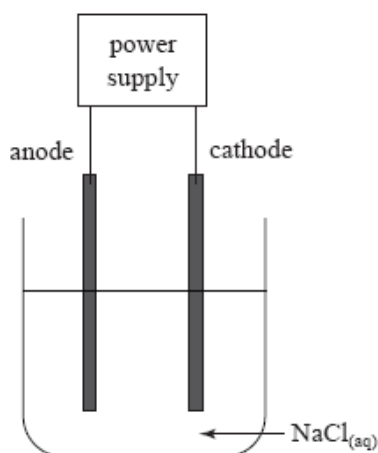
Question 4 (5 marks)

Calculate the pH of a sample of 1.5M CH_3COOH . Begin by writing the equation for the predominant equilibrium reaction. The K_a for the predominant equilibrium reaction is 1.80×10^{-5} .

Predominant Equilibrium Reaction:

Question 5 (6 marks)

Chlorine gas can be produced by the electrolysis of NaCl solution, as shown in the diagram below:



(a) Write a half-equation for the production of Cl_2 during the electrolysis. (2 marks)

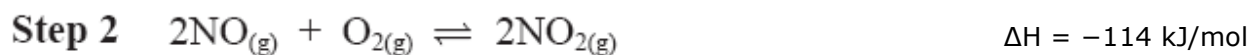
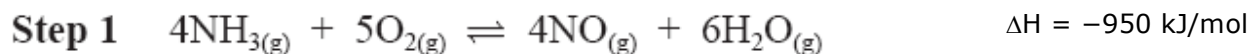
(b) State whether Cl_2 is produced at the positive electrode or at the negative electrode. (1 mark)

(c) Explain why sodium metal is not produced at the other electrode during this process. (2 marks)

(d) Identify a suitable electrolyte for the production of sodium metal. (1 marks)

Question 6 (15 marks)

The commercial production of nitric acid, HNO_3 , involves the steps summarised below:



(a) A catalyst is used in Step 1. State one advantage to the manufacturer of using a catalyst, giving a reason for your answer. (2 marks)

Advantage: _____

Reason: _____

(b) High pressure is used for the reaction in Step 2.

State and explain the effect of high pressure on the yield of $\text{NO}_{2(g)}$ in Step 2. (3 marks)

(c) (i) Write the equilibrium expression for the reaction in Step 3. (1 mark)

Question 6 continued

(ii) In a laboratory investigation of this reaction, $\text{NO}_{2(g)}$ was placed in a 1.0 L reaction vessel at 25°C and allowed to reach equilibrium. The data collected are shown in the table below:

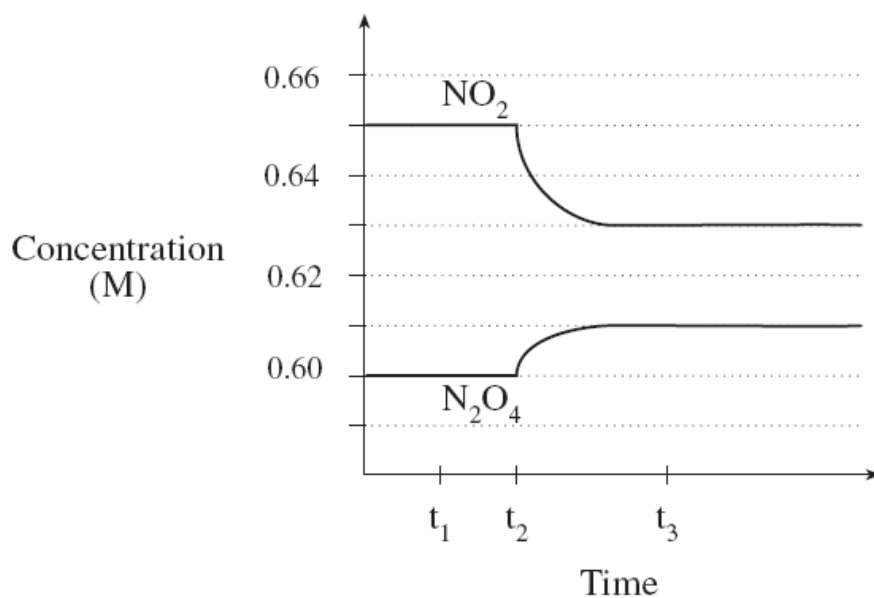
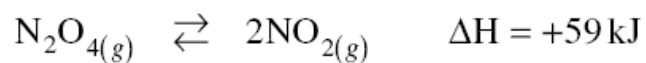
	$\text{NO}_{2(g)}$	$\text{N}_2\text{O}_{4(g)}$
initial moles	0.132	0
moles at equilibrium	x	0.0400

(ii) Calculate the value of x . (2 marks)

(iii) Hence show that $K_c = 15$ for this reaction at 25°C . (2 marks)

(iv) $K_c = 2.1$ for this reaction at 100°C . State and explain whether this reaction is exothermic or endothermic. (2 marks)

Consider the following diagram for the equilibrium:



(v) What change was applied at time t_2 ? Explain.

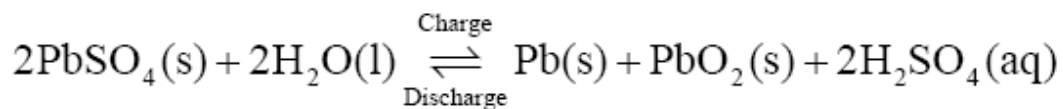
(3 marks)

Change: _____

Explanation:

Question 7 (5 marks)

The following reaction takes place in a lead-acid storage battery.



(a) State the half-equations taking place at the negative electrode (anode) and the positive electrode (cathode) during the discharge of this battery. (2 marks)

negative electrode (anode)

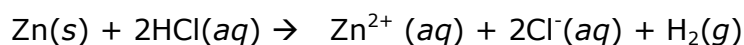
positive electrode (cathode)

(b) State **one** change in the electrolyte during the discharge process. (1 mark)

(c) State **one** advantage and **one** disadvantage of a lead-acid storage battery compared to a zinc-carbon battery. (2 marks)

Question 8 (7 marks)

Zinc metal and dilute hydrochloric acid solution react according to the equation:



The reaction starts slowly at room temperatures and gradually speeds up. The beaker containing the reaction becomes warmer as the reaction proceeds.

(a) Is the reaction exothermic or endothermic? Give a reason. (2 marks)

(b) What is the relative size of the activation energy? Explain. (2 marks)

(c) On the axes below draw an energy diagram for this reaction indicating reactants, products, ΔH and activation energy. (2 marks)



(d) A piece of copper wire wound around the zinc catalyses the reaction. Show the effect of the catalyst on the graph above with a dotted line. (1 mark)

END OF EXAM

Physical constants

$$F = 96\,500 \text{ C mol}^{-1}$$

$$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$$

$$1 \text{ atm} = 101\,325 \text{ Pa} = 760 \text{ mmHg}$$

$$0^\circ\text{C} = 273 \text{ K}$$

$$\text{Molar volume at STP} = 22.4 \text{ L mol}^{-1}$$

$$\text{Avogadro constant} = 6.02 \times 10^{23} \text{ mol}^{-1}$$

Ideal gas equation

$$pV = nRT$$

The electrochemical series

	E° in volt
$\text{F}_2(\text{g}) + 2\text{e}^- \rightarrow 2\text{F}^-(\text{aq})$	+2.87
$\text{H}_2\text{O}_2(\text{aq}) + 2\text{H}^+(\text{aq}) + 2\text{e}^- \rightarrow 2\text{H}_2\text{O}(\text{l})$	+1.77
$\text{Au}^+(\text{aq}) + \text{e}^- \rightarrow \text{Au}(\text{s})$	+1.68
$\text{Cl}_2(\text{g}) + 2\text{e}^- \rightarrow 2\text{Cl}^-(\text{aq})$	+1.36
$\text{O}_2(\text{g}) + 4\text{H}^+(\text{aq}) + 4\text{e}^- \rightarrow 2\text{H}_2\text{O}(\text{l})$	+1.23
$\text{Br}_2(\text{l}) + 2\text{e}^- \rightarrow 2\text{Br}^-(\text{aq})$	+1.09
$\text{Ag}^+(\text{aq}) + \text{e}^- \rightarrow \text{Ag}(\text{s})$	+0.80
$\text{Fe}^{3+}(\text{aq}) + \text{e}^- \rightarrow \text{Fe}^{2+}(\text{aq})$	+0.77
$\text{I}_2(\text{s}) + 2\text{e}^- \rightarrow 2\text{I}^-(\text{aq})$	+0.54
$\text{O}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l}) + 4\text{e}^- \rightarrow 4\text{OH}^-(\text{aq})$	+0.40
$\text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Cu}(\text{s})$	+0.34
$\text{S}(\text{s}) + 2\text{H}^+(\text{aq}) + 2\text{e}^- \rightarrow \text{H}_2\text{S}(\text{g})$	+0.14
$2\text{H}^+(\text{aq}) + 2\text{e}^- \rightarrow \text{H}_2(\text{g})$	0.00
$\text{Pb}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Pb}(\text{s})$	-0.13
$\text{Sn}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Sn}(\text{s})$	-0.14
$\text{Ni}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Ni}(\text{s})$	-0.23
$\text{Co}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Co}(\text{s})$	-0.28
$\text{Fe}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Fe}(\text{s})$	-0.44
$\text{Zn}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Zn}(\text{s})$	-0.76
$2\text{H}_2\text{O}(\text{l}) + 2\text{e}^- \rightarrow \text{H}_2(\text{g}) + 2\text{OH}^-(\text{aq})$	-0.83
$\text{Mn}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Mn}(\text{s})$	-1.03
$\text{Al}^{3+}(\text{aq}) + 3\text{e}^- \rightarrow \text{Al}(\text{s})$	-1.67
$\text{Mg}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Mg}(\text{s})$	-2.34
$\text{Na}^+(\text{aq}) + \text{e}^- \rightarrow \text{Na}(\text{s})$	-2.71
$\text{Ca}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Ca}(\text{s})$	-2.87
$\text{K}^+(\text{aq}) + \text{e}^- \rightarrow \text{K}(\text{s})$	-2.93
$\text{Li}^+(\text{aq}) + \text{e}^- \rightarrow \text{Li}(\text{s})$	-3.02

Periodic table of the elements

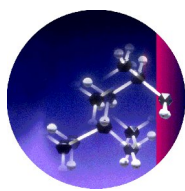
1 H 1.0																	2 He 4.0
3 Li 6.9	4 Be 9.0															9 F 19.0	10 Ne 20.1
11 Na 23.0	12 Mg 24.3															17 Cl 35.5	18 Ar 39.9
19 K 39.1	20 Ca 40.1	21 Sc 44.9	22 Ti 47.9	23 V 50.9	24 Cr 52.0	25 Mn 54.9	26 Fe 55.9	27 Co 58.9	28 Ni 58.7	29 Cu 63.6	30 Zn 65.4	31 Ga 69.7	32 Ge 72.6	33 As 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
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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)
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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**☐

2. **A**☐ **B**☐ **C**☐ **D**☐

3. **A**☐ **B**☐ **C**☐ **D**☐

4. **A**☐ **B**☐ **C**☐ **D**☐

5. **A**☐ **B**☐ **C**☐ **D**☐

6. **A**☐ **B**☐ **C**☐ **D**☐

7. **A**☐ **B**☐ **C**☐ **D**☐

8. **A**☐ **B**☐ **C**☐ **D**☐

9. **A**☐ **B**☐ **C**☐ **D**☐

10. **A**☐ **B**☐ **C**☐ **D**☐

11. **A**☐ **B**☐ **C**☐ **D**☐

12. **A**☐ **B**☐ **C**☐ **D**☐

13. **A**☐ **B**☐ **C**☐ **D**☐

14. **A**☐ **B**☐ **C**☐ **D**☐

15. **A**☐ **B**☐ **C**☐ **D**☐

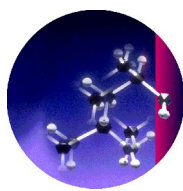
16. **A**☐ **B**☐ **C**☐ **D**☐

17. **A**☐ **B**☐ **C**☐ **D**☐

18. **A**☐ **B**☐ **C**☐ **D**☐

19. **A**☐ **B**☐ **C**☐ **D**☐

20. **A**☐ **B**☐ **C**☐ **D**☐



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SUGGESTED SOLUTIONS TO 2009 CHEMISTRY TRIAL EXAM 2

Section A

1 B		11 C	If a reaction proceeds the oxidant must be higher on the table than the reductant. 1 st reaction $X > Y$ 2 nd reaction $Y^+ > Z$ 3 rd reaction $X > Z$ $X > Y^+ > Z^+$
2 C		12 A	Electrochemical Cell, so object 1 is voltmeter. Electrons flow from X to Z thus X must be losing electrons and thus be the anode.
3 B		13 D	Rb^{2+} is a weaker oxidant than water, water will be reduced at the cathode to produce OH^- ions. The pH around the cathode will increase. Water is the only reductant present at anode and will be oxidised to H^+ ions. The pH will decrease around the anode.
4 D		14 B	$Pd^{2+} + 2e^- \rightarrow Pd$ $Ag^+ + e^- \rightarrow Ag$ If same number of mole flowing, then there will be half as many mole Pd produced as Ag. With their molar masses similar, there will be roughly double the mass of Ag produced.
5 B	Removing product will cause equilibrium to shift to the right to try and increase the amount of product.	15 A	Ni is a stronger reductant than Cl^- ions, so Ni will undergo oxidation to Ni^{2+} ions and Cl_2 will be reduced.
6 C	Adding HCl will cause reaction to move backwards using up some NH_3 . However, as HCl was added the equilibrium concentration will still be higher even though the reaction has moved backwards.	16 C	As reaction is endothermic, as temperature increase will cause K to increase.
7 A		17 B	Molten KBr, only K^+ and Br^- ions present so K^+ is reduced to K at the cathode and Br_2 at the anode.
8 C	$[H^+] = 10^{-14}/2.5$ $pH = -\log(10^{-14}/2.5) = 14.4$	18 B	$\Delta H = H(\text{products}) - \text{reactants}) = 300 - 250 = 50$ Endothermic $E_a \text{ forward} = 450 - 250 = 200$ $E_a \text{ reverse} = 450 - 300 = 150$
9 C	As reaction is endothermic, T increase will cause K increase and reaction moves to the right. $[H^+]$ increase and pH decreases. Solution remains neutral due to $[H^+] = [OH^-]$	19 D	At anode water is the only reductant in contact with the electrode, so water will undergo oxidation to oxygen.
10 B	$n(HCl) = 0.08 \times 0.02 = 0.0016 \text{ mol}$ $n(NaOH) = 0.05 \times 0.03 = 0.0015 \text{ mol}$ $n(HCl) \text{ xs} = 0.0016 - 0.0015 = 0.0001 \text{ mol}$ $[HCl] = 0.0001 / [(20 + 30)/1000] = 0.002M$ $pH = -\log(0.002) = 2.7$	20 C	Copper will not react at the cathode (-ve) electrode as copper is a reductant. Water will be reduced to hydrogen. The mass of copper is unaffected. Cations will move towards the negative electrode – to the right.

Section B ① = 1 mark**Question 1**

(a) (i) $\Delta H / \text{molar mass} = \text{Energy per gram}$

Petrol $5460/114 = 47.9$ Kerosene $10\,000/210 = 47.6$ Hydrogen $285/2 = 142.5$

Ethanol $1370/46 = 29.8$

Hydrogen has greatest energy per gram ①

(b) mass = $d \times V = 80\,000 \times 0.69 = 55\,200\text{g}$ ①

Mole = $55200\text{g} / 114 = 484.21\text{mol}$ ①

Energy = $484.21 \times 5460 = 2.64 \times 10^6 \text{ kJ}$ ①

(c) $1\text{mol H}_2 = 285\text{kJ}$

$x \text{ mol} = 2.64 \times 10^6 \text{ kJ}$

$x = 2.64 \times 10^6 / 285 = 9276.5\text{mol}$ ①

$pV = nRT$

$V(\text{H}_2) = \frac{9276.5 \times 8.31 \times 298}{100}$

$= 229720 = 2.30 \times 10^5 \text{ L}$ ①

Question 2

(a) Carbon dioxide produced. ①

(b) A larger surface area of crushed particles will have a larger area of contact and result in more fruitful collisions between particles. ①

A higher concentration will mean there are more acid particles present in the solution and more chance of successful collisions between particles. ①

Both of these situations will lead to an increase in the rate of the reaction. ①

(c) The temperature of the room will have been higher. ① The higher temperature will result in the particles moving more quickly ① and will have more energy to be able to overcome the activation energy barrier. ①

Question 3

a) $\text{Sn(s)} \rightarrow \text{Sn}^{4+}(\text{l}) + 4\text{e}^-$

b) $Q = 0.2 \times 5 \times 60 \times 60 = 3600\text{C}$ ①

$n(\text{e}) = Q/F = 3600/96500 = 0.0373 \text{ mol}$ ①

$n(\text{Sn}) = 0.0373 / 4$ ①

$m(\text{Sn}) = n \times 118.7 = 1.12\text{g}$ ①

Question 4

Predominant Reaction $\text{CH}_3\text{COOH (aq)} + \text{H}_2\text{O(l)} \rightarrow \text{CH}_3\text{COO}^- \text{ (aq)} + \text{H}_3\text{O}^+ \text{ (aq)}$ ①

$$K_a = \frac{[\text{CH}_3\text{COO}^-][\text{H}^+]}{[\text{CH}_3\text{COOH}]} \quad \text{①}$$

$$1.80 \times 10^{-5} = \frac{[\text{H}_3\text{O}^+]^2}{1.5} \quad \text{①}$$

$$[\text{H}^+] = 0.00519 \text{ M} \quad \text{①}$$

$$\text{pH} = -\log 0.00519 = \mathbf{2.3} \quad \text{①}$$

Question 5

a) $2\text{Cl}^- \text{ (aq)} \rightarrow \text{Cl}_2 \text{ (g)} + 2\text{e}^-$ ①

b) Positive ①

c) In aqueous solution water is a stronger oxidant than Na^+ ① and water will be preferentially reduced. ①

d) Molten NaCl. ①

Question 6

a) **Advantage:** Increase rate of reaction. ① As temperature decreases K increases however, rate of reaction will be slow so a catalyst is used to speed up rate and not compromise yield. ①

b) As pressure increases favours side with smaller mole of particles ①, in this reaction it is to the right. ① Thus $[\text{NO}_2]$ will increase. ①

$$\text{c) i) } K = \frac{[\text{N}_2\text{O}_4]}{[\text{NO}_2]^2} \quad \text{①}$$

ii) & iii)

	NO_2	N_2O_4
n(initially)	0.132	0
n (reacts)	$2 \times 0.0400 = 0.08$ ①	0.0400
n(At equilibrium)	$X = 0.132 - 0.08 = 0.052 \text{ mol}$ ①	0.0400 mol
Concentration at equilibrium	0.052 M	0.04M

$$\text{iii) } K = \frac{0.04}{(0.052)^2} \quad \text{①} = \mathbf{14.8 \text{ M}^{-1}} \quad \text{①}$$

iv) As K decreased when temperature increased the reaction is exothermic. ①① As energy is a product, increasing temperature will cause reaction to move backwards.

v) **Change:** Temperature decreased ❶ Reaction is endothermic as temperature decreases K decreases ❶, reaction moves backwards more N_2O_4 is produced. ❶

Question 7

a) **Anode** $\text{Pb (s)} + \text{SO}_4^{2-} (\text{aq}) \rightarrow \text{PbSO}_4 (\text{s}) + 2\text{e}^-$ ❶ **or** $\text{Pb (s)} \rightarrow \text{Pb}^{2+} (\text{aq}) + 2\text{e}^-$

Cathode $\text{PbO}_2 (\text{s}) + 4\text{H}^+ (\text{aq}) + \text{SO}_4^{2-} (\text{aq}) + 2\text{e}^- \rightarrow \text{PbSO}_4 (\text{s}) + 2\text{H}_2\text{O (l)}$ ❶

Or $\text{Pb}^{4+} (\text{aq}) + 2\text{e}^- \rightarrow \text{Pb}^{2+} (\text{aq})$

b) Concentration decreases/ density decreases/ pH increases ❶

c) **Advantage** rechargeable/ delivers large amounts of energy ❶

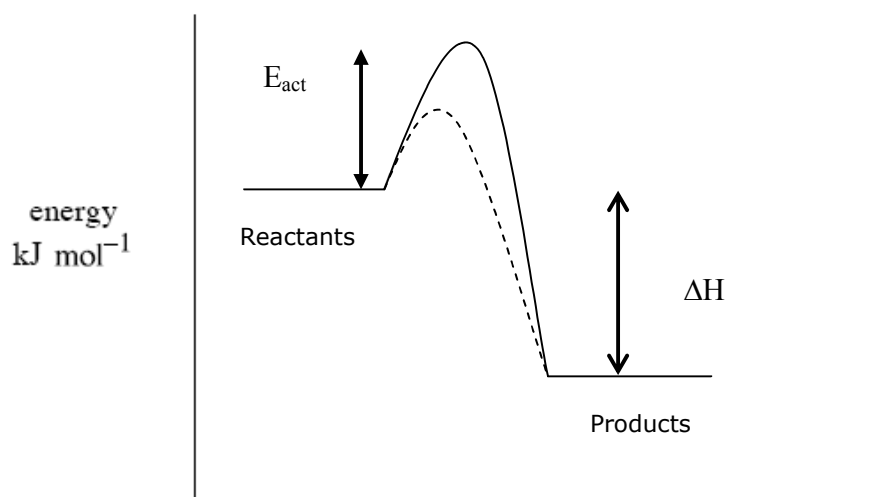
Disadvantage bulky/ acid spillage/ heavy/ toxic ❶

Question 8

a) Exothermic ❶ Heat is produced during reaction. ❶

b) Small ❶ as reaction proceeds at room temperature. ❶

c) ❶❶



d) dotted line ❶