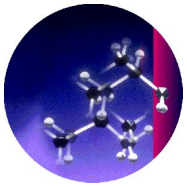

CHEMOLOGY EDUCATION SERVICES

Name:_____

Victorian Certificate of Education
2009 CHEMISTRY Unit 4
TRIAL EXAM

Time allowed: 1 hour 30 minutes

QUESTION AND ANSWER BOOKLET

Structure of booklet

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.

Data Pages may be found at
http://www.vcaa.vic.edu.au/vce/studies/chemistry/chem1_sample_2008.pdf

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 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:

$$ZnS\ (s) + H_2SO_4\ (aq) + \tfrac{1}{2}\ O_2\ (g) \rightarrow ZnSO_4(aq) + S\ (s) + H_2O\ (l)$$

What would increase the fraction of successful collisions?

I	increasing temperature
II	increasing surface area of ZnS
III	increasing $[H_2SO_4]$
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 (forward) = 250 kJ
E_a (reverse) = 100 kJ
If a catalyst is added to the reaction, which of the following values could be correct?

	$E_{a\,(\text{forward})}$ (kJ)	$E_{a\,(\text{reverse})}$ (kJ)	$\Delta H_{(\text{forward})}$ (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.

$$NH_4Cl(s) \rightleftarrows NH_3(g) + HCl(g) \qquad \Delta H = +176\,kJ$$

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?

	$[NH_3]$	[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:

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

Initially, 1.6 mol SO_3 is placed in a 3.0 L container. At equilibrium, $[O_2] = 0.15M$. What is the value of K*eq* ?

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

Question 9

$$\text{Energy} + \ 2H_2O\ (l) \ \Leftrightarrow \ H_3O^+\ (aq) \ + \ OH^-\ (aq)$$

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?

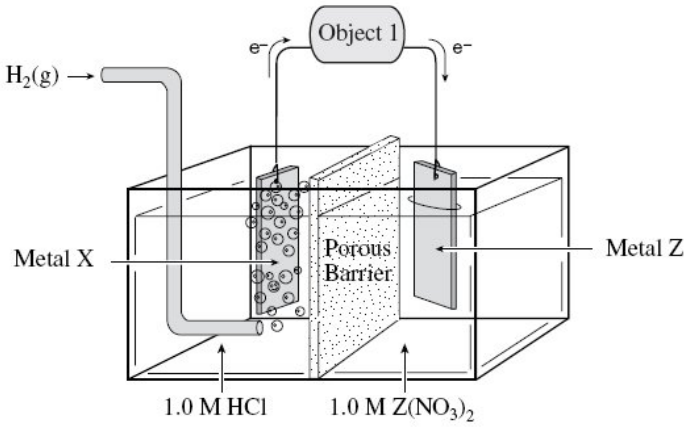
A 1.1
B 2.7
C 4.0
D 7.0

Consider the following spontaneous redox equations:
$X + Y \rightarrow X^- + Y^+$
$Y^+ + Z \rightarrow Y + Z^+$
$Z + X \rightarrow Z^+ + X^-$

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

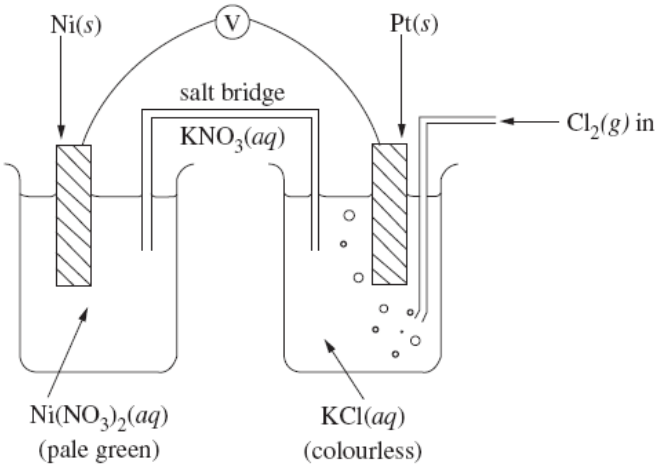
Question 13
The electrolysis of aqueous Rb_2SO_4 solution using carbon electrodes produces changes in the solution around the electrodes. How will the pH change around the anode and the cathode?

	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 $PdCl_2(aq)$ and $AgNO_3(aq)$ 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. $Ni_{(s)}$ is oxidised at the anode and $Cl_{2(g)}$ is reduced at the cathode.
B. $Ni^{2+}_{(aq)}$ ions are reduced at the cathode and $Cl_{2\ (g)}$ 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:

$$N_2O_4(g) \quad \Leftrightarrow \quad 2NO_2(g) \qquad \Delta H = 59 \text{ kJ mol}^{-1}$$

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.

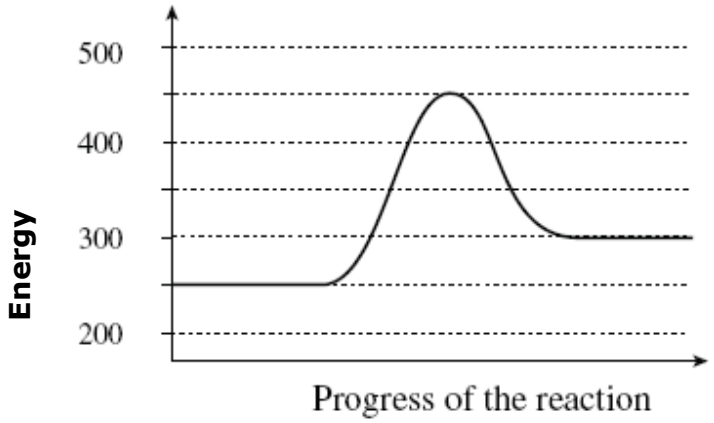
C The value of the equilibrium constant will increase.

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

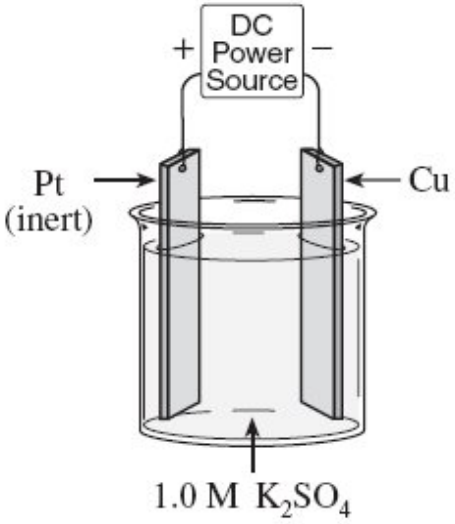
Question 18
Consider the following Energy Profile diagram for a reversible reaction:



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. $K \rightarrow K^+ + e^-$

B. $Cu \rightarrow Cu^{2+} + 2\ e^-$

C. $2SO_4^{2-} \rightarrow S_2O_8^{2-} + 2e^-$

D. $2H_2O \rightarrow O_2 + 4H^+ + 2e^-$

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 $H_2(g)$, NaCl (s).

Question 1 (6 marks)

The table shows four fuels and their various properties.

Property	*Petrol*	*Kerosene*	*Hydrogen*	*Ethanol*
Heat of combustion (kJ mol^{-1})	5460	10 000	285	1370
Boiling point (°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.

$$2HCl_{(aq)} + CuCO_{3(s)} \rightarrow H_2O_{(\ell)} + CO_{2(g)} + Cu^{2+}{}_{(aq)} + 2Cl^{-}{}_{(aq)}$$

(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:

_____

_____

_____

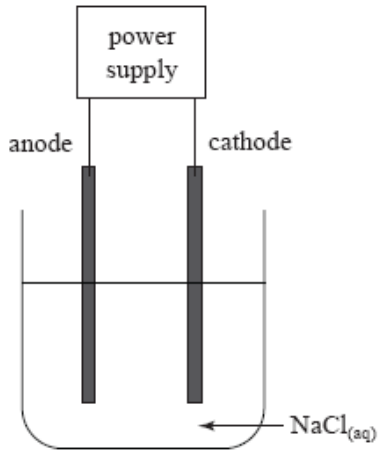
_____

_____

_____

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:

Step 1 $4NH_{3(g)} + 5O_{2(g)} \rightleftharpoons 4NO_{(g)} + 6H_2O_{(g)}$ $\Delta H = -950$ kJ/mol

Step 2 $2NO_{(g)} + O_{2(g)} \rightleftharpoons 2NO_{2(g)}$ $\Delta H = -114$ kJ/mol

Step 3 $2NO_{2(g)} \rightleftharpoons N_2O_{4(g)}$ $\Delta H = -59$ kJ/mol

Step 4 $3N_2O_{4(g)} + 2H_2O_{(g)} \rightleftharpoons 4HNO_{3(aq)} + 2NO_{(g)}$ $\Delta H = -117$ kJ/mol

(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 $NO_{2(g)}$ 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, $NO_{2(g)}$ 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:

	$NO_{2(g)}$	$N_2O_{4(g)}$
initial moles	0.132	0
moles at equilibrium	x	0.0400

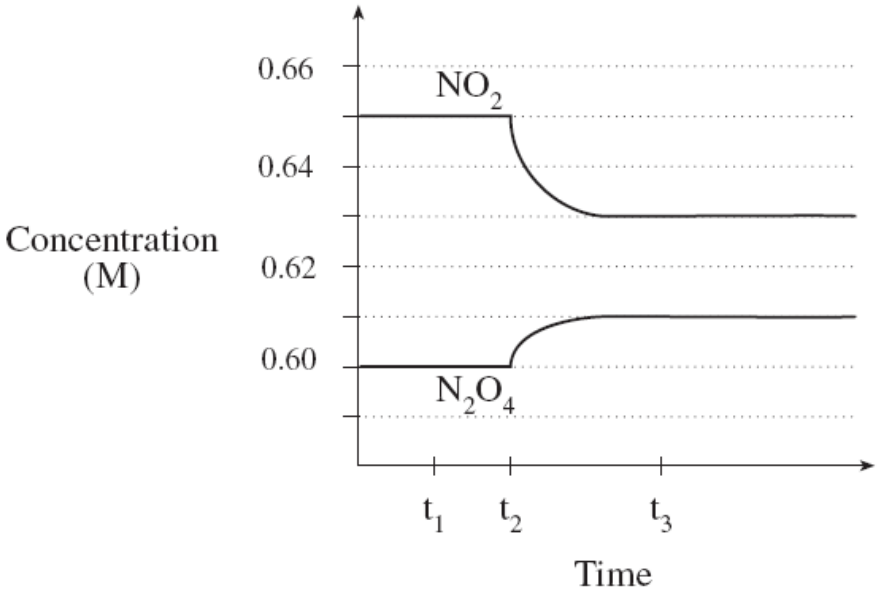
(ii) Calculate the value of x. (2 marks)

(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:

$$N_2O_{4(g)} \rightleftarrows 2NO_{2(g)} \qquad \Delta H = +59\,kJ$$



(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.

$$2PbSO_4(s) + 2H_2O(l) \underset{\text{Discharge}}{\overset{\text{Charge}}{\rightleftharpoons}} Pb(s) + PbO_2(s) + 2H_2SO_4(aq)$$

(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:

$$Zn(s) + 2HCl(aq) \rightarrow Zn^{2+}(aq) + 2Cl^{-}(aq) + H_2(g)$$

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)

_____

_____

_____

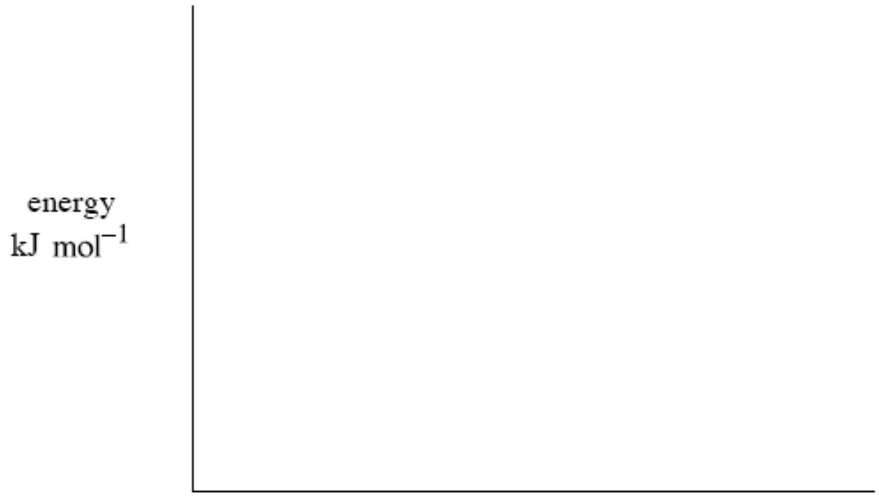
(b) What is the relative size of the activation energy? Explain. (2 marks)

_____

_____

_____

(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

$F = 96\,500$ 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 = 6.02×10^{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
$O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l)$	+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

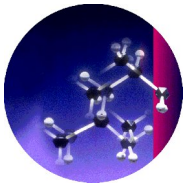
1 H 1.0																	2 He 4.0
3 Li 6.9	4 Be 9.0											5 B 10.8	6 C 12.0	7 N 14.0	8 O 16.0	9 F 19.0	10 Ne 20.1
11 Na 23.0	12 Mg 24.3											13 Al 27.0	14 Si 28.1	15 P 31.0	16 S 32.1	17 Cl 35.5	18 Ar 39.9
19 K 39.1	20 Ca 40.1	21 Sc 44.9	22 Ti 47.9	23 V 50.9	24 Cr 52.0	25 Mn 54.9	26 Fe 55.9	27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