SCH4U: Practice Exam

SCH4U_07 - 08

Energy in Chemistry

1. Which of the following correctly describes a reaction that absorbs heat from the surroundings?

a. the reaction is endothermic b. ΔH for this reaction is negative
c. the reactants have more potential energy than the productsd. the reaction is exothermic
e. the activation energy for the forward reaction is less than for the reverse reaction.

2. The specific heat of ethyl alcohol is 2.45J / g°C and that of silver is 0.235J / g°c. Therefore, 10.0J of energy delivered to 10.0g of each substance:

(a) raises the temperature of both by the same number of degrees
(b) raises the temperature of the ethyl alcohol more than that of the silver
(c) raises the temperature of the silver more than that of the ethyl alcohol
(d) raises the heat capacity of the silver more than that of the ethyl alcohol
changes the specific heat of the silver more than that of ethyl alcohol

3. Consider the following equations:

$$C_{(s)} + O_{2\,(g)} \longrightarrow CO_{2\,(g)} \qquad \Delta H^0 = -395\text{ kJ}$$
$$CO_{(g)} + \frac{1}{2} O_{2\,(g)} \longrightarrow CO_{2(g)} \qquad \Delta H^0 = -284\text{ kJ}$$

What is the enthalpy change for the oxidation of carbon to carbon monoxide for the following equation?

$$C_{(s)} + \frac{1}{2} O_{2\,(g)} \longrightarrow CO_{(g)}$$

a. – 679 kJ b. – 395 kJ c. – 346 kJ d. – 111 kJ e. + 173 kJ

4. The heats of formation of NO_2 and N_2O_4 are +33.2 and +9.2 kJ mol^{-1} respectively. Calculate the enthalpy change for the reaction:

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

A. -57.2 kJ B. -24.0 kJ
C. 41.4 kJ D. 75.6 kJ

5. Consider the following equation for the combustion of hydrogen:

$$H_2(g) + {}^1/_2\, O_2(g) \longrightarrow H_2O(g) + 243\text{ kJ}$$

In order to produce 1215 kJ of heat, how many grams of H_2 must burn?
a. 12.0 g b. 0.100 g c. 10.0 g d. 0.250 g e. 8.00 g

6. Which equation represents the bond enthalpy for the H--F bond?

a) $HF_{(g)} \dashrightarrow H_{(g)} + F_{(g)}$
b) $HF_{(g)} \dashrightarrow \frac{1}{2} H_{2\,(g)} + \frac{1}{2} F_{2\,(g)}$
c) $HF_{(aq)} \dashrightarrow H_{(aq)}^{+1} + F_{(aq)}^{-1}$
d) $HF_{(g)} \dashrightarrow H_{(g)}^{+1} + F_{(g)}^{-1}$

7. When the substances $H_2(g)$, $O_2(g)$, $H_2O(l)$ are arranged in order of increasing entropy values at 25°C, what is the correct order?

A. $H_2(g)$, $O_2(g)$, $H_2O(l)$ B. $H_2(g)$, $H_2O(l)$, $O_2(g)$

C. $O_2(g)$, $H_2(g)$, $H_2O(l)$ D. $H_2O(l)$, $H_2(g)$, $O_2(g)$

8. What is true about the signs of ΔH and ΔS for a reaction that is spontaneous at low temperatures but becomes non-spontaneous at higher temperatures?

	ΔH	**ΔS**
A.	-	-
B.	-	+
C.	+	+
D.	+	-

9. In which reaction is the change in entropy, Δ S, closest to zero?

A. $SO_{2(g)} + \frac{1}{2} O_{2(g)} \longrightarrow SO_{3(g)}$
B. $Br_{2(l)}$ S $\longrightarrow Br_{2(g)}$
C. $H_{2(g)} + I_{2(g)} \longrightarrow 2\,HI_{(g)}$
D. $3\,Ca_{(s)} + N_{2(g)} \longrightarrow Ca_3N_{2(s)}$

10. The entropy change on vaporization, ΔS_{vap}, of a compound or element is ...

A. always positive
B. always negative
C. sometimes positive and sometimes negative
D. only if the experiment is performed on a space lab.

11. Given that the normal freezing point of ammonia is - 78 ^{0}C. Predict the signs of ΔH, ΔS, and ΔG for ammonia when it freezes at - 80 ^{0}C and 101.3 kPa.

	ΔH	**ΔS**	**ΔG**
A.	-	-	-
B.	-	-	0
C.	+	+	0
D.	+	-	+

12. If it is necessary to employ an electric current continuously in order for a reaction to take place, which one of the following must always be true for that reaction?

A. $\Delta H > 0$ B. $\Delta H < 0$ C. $\Delta G > 0$ D. $\Delta G < 0$

Rates

13. Which best explains why increasing concentration increases reaction rate?

a. The collisions become more effective.

b) The average kinetic energy increases.

c) The collision frequency increases.

d) The activation energy increases.

e. The activation energy decreases

14. Raising the temperature of a reaction system increases the rate of reaction but does <u>NOT</u> increase the

a) Average velocity of the reacting molecules

b) Number of collisions per second

c) Number of reaction- producing collisions per second

d) Average kinetic energy

e) Activation energy

15. In a chemical reaction at constant temperature, the addition of a catalyst:

a) Increases the concentration of products at equilibrium.

b) Increases the fraction of molecules with more than a given kinetic energy.

c) Lowers the amount of energy released in the overall reaction.

d) Provides and alternative reaction pathway with a different activation energy.

e) Does not affect the reaction rate.

For the <u>next four questions</u> use the following reaction mechanism:

$2A \longrightarrow B$		slow
$B + C \longrightarrow D + E$		fast
$C + D \longrightarrow E + F$		fast

16. What is the equation for this overall reaction?

a) $2A + 2C \longrightarrow 2E + F$

b) $2A + B + 2C \longrightarrow 2E + F$

c) $2A + B + 2C \longrightarrow D + E + F$

d) $2A + B + 2C + D \longrightarrow D + 2E + F$

17. The concentration of which substance would have the most effect on the rate of the overall reaction?

a) A b) B c) C d) D e) E

18. The species B is :

a. Product b. catalyst c. Reactant d. reaction intermediate

19. The rate law for this reaction is:

a. Rate = k [A] b. Rate = k $[A]^2$ c. Rate = k [B][C] d. Rate = k $[A]^2$ $[B]^2$

20. The overall rate of any chemical reaction is most closely related to :

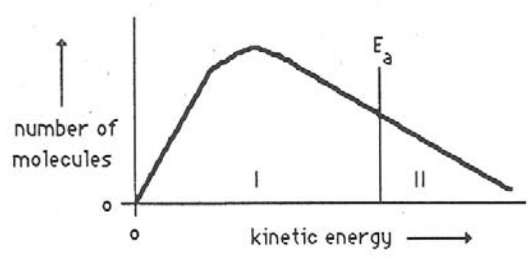
a. the overall reaction

b. the number of steps in the reaction

c. the fastest step in the reaction

d. the slowest step in the reaction

21. Consider the following graph of the kinetic energy distribution among molecules at temperature T.



If the temperature were increased how would the resulting graph differ from the one above?

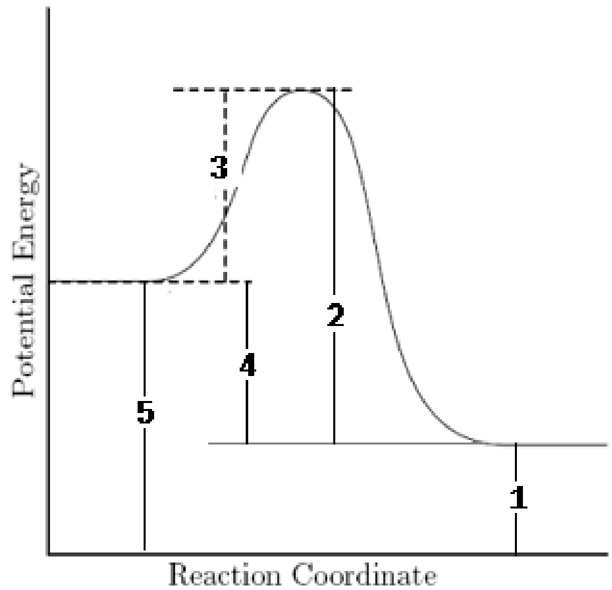
(a) both areas I and II would increase

(b) both areas I and II would decrease

(c) area I would increase and area II would decrease

(d) area I would decrease and area II would increase

The potential energy diagram for a reaction is shown below, Use it to answer the following five questions.



22. Which of the following statements is correct?

a. The reaction is an exothermic

b. The reaction is endothermic

c. the reaction is likely to occur in one step.

d. the activation energy for the reverse reaction is less than for the forward reaction.

23. The activation energy for the forward reaction is given by:

a. 1 b. 2 c. 3 d. 4 e. 5

24. The activation energy for the reverse reaction is given by:

a. 1 b. 2 c. 3 d. 4 e. 5

25. If a catalyst was added to this reaction, it would have an effect on:

a. 1 b. 2 c. 3 d. 2+3 e. 3+4

26. If the temperature was increased in this reaction, it would have an effect on:

a. 1 b. 2 c. 3 d. 4 e. None of the above

Chemical Systems and Equilibrium

The **next six questions** refer to the following reaction:

In the manufacture of an important organic solvent, toluene (C_7H_8), from methyl cyclohexane (C_7H_{14}), the following reaction occurs:

$$C_7H_{14(g)} \rightleftharpoons C_7H_{8\,(g)} + 3\,H_{2\,(g)}$$

27. Using only the information given by the equation, which of the following changes would **increase** the **molar concentration of $C_7H_{8\,(g)}$**, at equilibrium?

(a) decrease the pressure (b) increase the temperature

(c) decrease the concentration of $C_7H_{14(g)}$ (d) decrease the temperature (e) add a catalyst

28. Calorimetric studies show that the **forward reaction is endothermic**. Based on this information, which one, if any, of the following additional changes would increase the molar concentration of $C_7H_{8(g)}$ at equilibrium?

(a) increase the pressure at constant temperature (b) increase the temperature at constant pressure

(c) decrease the concentration of $C_7H_{8(g)}$ (d) add a catalyst (e) none of the above

29. In order to reach equilibrium within a shorter interval of time, which one, if any, of the following changes would be appropriate?

(a) decrease the pressure (b) decrease the temperature

(c) decrease the concentration of $C_7H_{14(g)}$ (d) add a catalyst (e) none of the above

30. The natural tendency toward **lower potential energy** tends to:

(a) increase the randomness of this system (b) promote formation of $C_7H_{8(g)}$ in this reaction

(c) oppose the tendency toward maximum randomness in this system (d)increase the volume of this system

31. The **volume of the system is decreased** at a constant temperature. A new equilibrium is established by a shift of the original equilibrium to the:

a. Left and [$C_7H_{14(g)}$] increases b. Right and [$C_7H_{8\,(g)}$] increases

c. Left and [$C_7H_{14(g)}$] remains unchanged d. Right and [$C_7H_{8\,(g)}$] remains unchanged

32. The temperature of the above equilibrium system is increased while kept at a constant volume. A new state of equilibrium is established in which there is:

a. an increase in [$C_7H_{14(g)}$] and a decrease in K_{eq} b. an increase in [$C_7H_{8\,(g)}$] and an increase in K_{eq}

c. a decrease in [$C_7H_{14(g)}$] and a decrease in K_{eq} d. an increase in [$C_7H_{8\,(g)}$] and a decrease in K_{eq}

The next three questions deal with the following equilbrium situation:

$$H_2O_{(g)} \quad + \quad CO_{(g)} \rightleftharpoons H_{2(g)} \quad + \quad CO_{2(g)} \quad + \quad 42 \text{ kJ}$$

5.0 mol of $H_2O_{(g)}$ and 4.0 mol of $CO_{2\,(g)}$ are placed in a 1.0 L reaction vessel. The vessel is heated to reach temperature T_1 and this temperature is maintained as the system is allowed to come to equilbrium. After equilibrium has been established, an analysis of the equilbrium mixture indicates that 2.0 mol of $CO_{2\,(g)}$ are present.

33. How many moles of $H_2O_{(g)}$ are present at equilbrium?

a. 0.50 b. 1.0 mol c. 2.0 mol d. 2.5 mol e. 3.0 mol

34. Given the equilibrium concentrations at temperature T_1 were determined to be:

$[H_2O] = 0.40$ mol/L $[CO] = 1.00$ mol/L $[H_2] = 0.40$ mol/L $[CO_2] = 0.60$ mol/L

thus the numerical value of the equilibrium constant at temperature T_1 would be:

a. 0.40 b. 0.60 c. 1.0 d. 1.6 e. 0.72

35. What would the value of the equilibrium constatnt be, if the reaction were allowed to come to equilbrium at a temperature higher than T_1?

a. less than the constant for T_1 b. greater than the constant for T_1

c. the same as the value for T_1

d. more data are necessary to predict the relative value at a temperature above T_1

e. it is impossible to predict the relative values of the equilibrium constants

The solubility product constant, **Ksp**, values for some fluoride compounds are given below. Use these to answer the **next three questions**.

SALT	**Ksp at 25˚C**
MgF_2	6.60×10^{-9}
$Ca\ F_2$	3.9×10^{-11}
$Sr\ F_2$	2.9×10^{-9}
$Ba\ F_2$	1.7×10^{-6}
$Pb\ F_2$	3.6×10^{-8}

36. Which one of the compounds listed in the table is the **least** soluble in water at 25 ˚C?

a) MgF_2 b) $Ca\ F_2$ c) $Sr\ F_2$ d) $Ba\ F_2$ e) $Pb\ F_2$

37. How many grams of $Pb\ F_2$ will dissolve in 1.00 L of solution at 25 ^{O}C.

A. 2.08×10^{-3} b. 0.51 c. 5.1 d. 36.1

38. The solubility of HgF is 1.7×10^{-7} M at 25 ^{O}C. The solubility product constant, **Ksp**, for HgF is:

a. 2.9×10^{-14} b. 1.7×10^{-7} c. 3.4×10^{-7} d. 4.1×10^{-4}

Acid – Base Equilibria

39. The conjugate acid of HCO_3^- is:

A. H_3O^+ B. CO_2 C. CO_3^{2-} D. H_2CO_3

40. The hydrogen carbonate ion, HCO_3^{-1}, may act as an acid or a base in aqueous solution in terms of the Bronsted- Lowry definitions. In which one of the equations below is it acting as an **acid**?

A. $HCO_3^{-1}{}_{(aq)} + H_2O_{(l)} \rightleftharpoons H_2CO_{3\,(aq)} + OH^{-1}{}_{(aq)}$

B. $HCO_3^{-1}{}_{(aq)} + H_3O^{+1}{}_{(aq)} \rightleftharpoons H_2CO_{3\,(aq)} + H_2O_{(l)}$

C. $HCO_3^{-1}{}_{(aq)} + H_2O_{(l)} \rightleftharpoons CO_3^{-2}{}_{(aq)} + H_3O^{+1}{}_{(aq)}$

D. $HCO_3^{-1}{}_{(aq)} + OH^{-1}{}_{(aq)} \rightleftharpoons H_2CO_{3\,(aq)} + O^{-2}{}_{(aq)}$

41. Which chemical species could behave as **both** a Bronsted base and as a Bronsted acid?

A. HSO_4^- B. CO_3^{2-} C. NH_4^+ D. Such a species does not exist.

42. In which one of the following reactions is the species HSO_4^- acting as a **Bronsted base**?

A. $HSO_4^-(aq) + H_3O^+(aq) \rightleftharpoons H_2SO_4(aq) + H_2O(l)$

B. $HSO_4^-(aq) + OH^-(aq) \rightleftharpoons SO_4^{2-}(aq) + H_2O(l)$

C. HSO_4-$(aq) + H_2O(l) \rightleftharpoons SO_4^{2-}(aq) + H_3O^+(aq)$

D. $HSO_4^-(aq) + 2H^+(aq) + 2e \rightleftharpoons HSO_3^-(aq) + H_2O(l)$

The following table refers to the **next two questions**:

Acid	**pKa**
HCOOH	3.75
C_6H_5COOH	4.2
H_2CO_3	6.71
HCN	9.23

43. The weakest acid is:

a. HCOOH b. C_6H_5COOH c. H_2CO_3 d. HCN

44. The weakest base is:

a. $HCOO^{-1}$ b. $C_6H_5COO^{-1}$ c. HCO_3^{-1} d. CN^{-1}

45. For sulfurous acid the $\mathbf{Ka_1}$ =

a. $[SO_3^{2-}][H^{1+}]^2 / [H_2SO_3]$
b. $[HSO_4^{2-}][H^{1+}] / [H_2SO_3]$
c. $[SO_3^{1-}][H^{1+}]^2 / [H_2SO_3]$
d. $[HSO_3^{1-}][H^{1+}] / [H_2SO_3]$

46. For cyanide ion (CN^{1-}) the K_b =

a. $[OH^{1-}][HCN] / [CN^{1-}]$
b. $[CN^{1-}] / [OH^{1-}][HCN]$
c. $[OH^{1-}][HCN^{1-}] / [CN]$
d. $[C^{4-}][N^{3+}] / [CN^{1-}]$

47. If the Ka of a weak acid is 1.6 10^{-8}, the Kb of its conjugate base partner must be which of the following?

a. 6.20 b. 1.0 10^{-14} c. 6.8 10^{-7} d. 6.3 10^{-7} e. 7.80

48. The pH of a 1.24 mol/L solution of the weak, monoprotic acid $HCN_{(aq)}$ if its K_a = 6.2 10^{-10} is:

a. 1.24 b. 4.56 c. 9.26 d. 11.23

49. If the Kb of a 0.58 mol/L solution of weak base is 1.8 10^{-10}, what is its pH ?

A. 4.99 b. 1.76 x 10^{-5} c. 9.00 d. 13.42

50. What is the pH of a solution prepared by adding 0.50 mol LiOH to 1.0 L of 0.30 M HNO_3?

a. 0.20 b. 0.70 c. 13.30 d. 13.80

51. Which of the following salts acts like an acid when added to water?

a. ammonium nitrate
b. potassium nitrite
c. iron(III) nitrate
d. both a and b
e. both a and c

52. Which of the following salts acts like a base when added to water?

a. sodium perchlorate
b. potassium nitrite
c. lithium sulfite
d. both a and b
e. both b and c

53. Which of the following salts could be combined with CH_3COOH to form a buffer?

a. sodium oxalate b. iron(III) gluconate c. sodium acetate d. manganous cyanate

54. For the chemical system:

$$KOH_{(s)} + HBr_{(aq)} \longrightarrow KBr_{(aq)} + H_2O_{(l)} + 45 \text{ kJ}$$

which of the following is true?

a. entropy has increased and enthalpy has decreased
b. entropy has decreased and enthalpy has increased
c. both entropy and enthalpy have decreased
d. both entropy and enthalpy have increased
e. heat of neutralization = 45 kJ/mol of Hbr

Electrochemistry

55. Manganese (Mn) has an oxidation number of +6 in:

a. MnO_4^{-2} b. Mn^{+2} c. MnO_2 d. MnO_4^{-1}

56. In $Fe_2(SO_4)_3$ the oxidation numbers of Fe, S and O respectively are:

a. +2, +3, −4 b. +3, +6, −2 c.. +2, +4, −8 d. +2, +4, −2

57. Which substance in the following reaction has undergone oxidation?

$$2\,MnO_4^{-1}{}_{(aq)} + 5\,C_2O_4^{-2}{}_{(aq)} + 16\,H^{+1}{}_{(aq)} \longrightarrow 2\,Mn^{+2}{}_{(aq)} + 10\,CO_{2(g)} + 8\,H_2O_{(l)}$$

a. $MnO_4^{-1}{}_{(aq)}$ b. $Mn^{+2}{}_{(aq)}$ c. $C_2O_4^{-2}{}_{(aq)}$ d. $CO_{2(g)}$

58. Consider the following unbalanced redox reaction:

$$ClO_3^{-1} + Fe^{+2} + H^{+1} \longrightarrow Cl^{-1} + Fe^{+3} + H_2O$$

The coefficients in the balanced equation are, from left to right:

a. 1, 1, 6, 1, 1, 3 b. 1, 2, 6, 1, 2, 3 c. 2, 3, 12, 2, 3, 6 d. 1, 6, 6, 1, 6, 3

59. Experiments were performed with four strips of metals *A, B, C,* and *D*, and their corresponding nitrate solutions $A(NO_3)_2$, $B(NO_3)_2$, $C(NO_3)_2$, and $D(NO_3)_2$. Metal D was placed in each of the solutions and reactions were observed only in solutions containing A^{+2} and B^{+2} ions. Metal *B* did not react in any of the solutions. Metal *C* reacted in the solution containing D^{+2} ions, but was not tested in the other solutions. A list of the metals in order of decreasing strength as reducing agents (strongest reducing agent is listed first) is:

a. *B A D C* b. *C B D A* c. *C D A B* d. *D A C B*

60. Which of the following best describes the term electrolysis?

A. A process that uses electrical energy to cause a spontaneous reaction.
B. A process that generates electrical energy using a non-spontaneous reaction.
C. A process that generates electrical energy using a spontaneous reaction.
D. A process that uses electrical energy to cause a non-spontaneous reaction

Problems

1. For the reaction: $2\ N_2O_5\,(g) \rightarrow 4\ NO_2\,(g) + O_2\,(g)$ $\quad \Delta H\,0 = +126.4$ kJ

a. Use Table of Standard enthalpies of formation to determine the enthalpy of formation of N_2O_5.

b. State the sign of ΔS and ΔG that you would expect for this reaction.

2. Given the following reaction with experimental data:

$$C_4H_{11}CF_{(aq)} + OH^{-1}_{(aq)} \longrightarrow C_4H_{11}COH_{(aq)} + F^{-1}_{(aq)}$$

Trial	Initial $[C_4H_{11}CF]$ (mol/L)	Initial $[OH^-]$ (mol/L)	Initial Rate of Formation of F^- (mol/L/s)
1	0.10	0.20	5.5×10^{-4}
2	0.20	0.20	1.1×10^{-3}
3	0.10	0.40	5.5×10^{-4}

a) Determine the order of the reaction with respect to $C_4H_{11}CF$

b) Determine the order of the reaction with respect to OH^-

c) What is the overall order of the reaction ?

d) Write the rate law expression for the reaction.

e) Determine the value of the rate law constant for the reaction.

f) State the molecularity of the reaction.

g) State the effect of doubling the concentration of $C_4H_{11}CF$ and the concentration of the OH^{-1} on the rate of the reaction.

3. Given the equation:

$$2\ A_{(g)} + B_{(g)} \rightleftharpoons 3\ C_{(g)} + D_{(g)} \qquad \Delta H^0 = -315.9 \text{ kJ}$$

a) Write the equilibrium law expression (K_c) for the above reaction.

b) When equal volumes of A and B are combined in a 3.5 L flask, their initial concentrations were each 1.75 mol/L. Once equilibrium is reached, the equilibrium concentration of C , is [C] = 0.65 mol/L. Determine the K_c for this reaction.

4. The solubility product constant (K_{sp}) of $Ag_2CrO_{4\,(s)}$, in water is 5.02×10^{-13} at 25 ºC. What is the solubility of silver chromate (in g/L) at 298 K?

5. Hypobromous acid, $HOBr_{(aq)}$, has a $K_a = 3.75 \times 10^{-8}$ at a given temperature. Calculate the pH of a 0.225 M solution of hypobromous acid. State clearly any assumptions you have made at arriving your answer.

6. A new drug obtained from the seeds of a strange Colombian plant was found to be a weak organic base. A solution of this weak base has a concentration of 0.0100 mol /L, and a pH of 10.8. Determine the K_b for the drug.

7. Oxalic acid is a diprotic acid. 0.200 g of oxalic acid, $H_2C_2O_4$ was neutralized with 35.5 mL of $NaOH_{(aq)}$. Determine the concentration of the $NaOH_{(aq)}$.

8. An electrochemical cell consists of a compartment with a zinc electrode in contact with 1.0 mol/L $Zn(NO_3)_{2\,(aq)}$, and a compartment with a silver electrode in contact with 1.0 mol/L $Ag(NO_3)_{(aq)}$. Ammonium nitrate, $NH_4NO_{3\,(aq)}$, is placed in the salt-bridge.
The standard reduction potentials are:

$$Ag_{(aq)}^{+1} + e^{-1} \rightleftharpoons Ag_{(s)} \qquad E^0 = +0.80\ V$$

$$Zn_{(aq)}^{+2} + 2e^{-1} \rightleftharpoons Zn_{(s)} \qquad E^0 = -0.76\ V$$

a. For the above cell, write the two half-reactions that will occur at each electrode.

b. State which of the two metals silver or zinc is acting as the anode and which the cathode and state the polarity of each electrode.

c. Write the overall reaction for the cell and calculate the standard cell potential.

d. State the direction of the electron flow.

e. State the direction of the ion flow in the salt-bridge.

f. State the oxidizing agent and state what is oxidized.

g. Write the standard cell notation for the spontaneous reaction occurring in the cell.

9. Molten magnesium chloride is electrolysed. Use the following standard reduction potentials to answer the following questions:

$$Mg_{(aq)}^{+2} + 2e^{-1} \rightleftharpoons Mg_{(s)} \qquad E^0 = -2.36\ V$$

$$\tfrac{1}{2}\,Cl_{(aq)}^{-1} + e^{-1} \rightleftharpoons Cl^{-1}{}_{(aq)} \qquad E^0 = +1.36\ V$$

a. Write the two half-reactions that will occur at each electrode.

b. State the products at each electrode

c. State the polarity of each electrode.

d. Write the overall reaction for the cell and calculate the standard cell potential.

e. Is the reaction spontaneous or non-spontaneous.

f. State the sign of ΔG^0.

g. If **dilute** aqueous magnesium chloride is electrolysed, a different product is obtained at each electrode. Identify the product formed at each electrode, the overall E^0 value and write an overall equation, showing the formation of the product at each electrode.