SCH4U1
EXR03

Name:
Date:

SCH 4U1 – Practice Exam

ANSWERS

MARK DISTRIBUTION:

SECTION	MARKS	TOTAL
PART A – MULTIPLE CHOICE	30	
PART B - FILL IN THE BLANK	14	
PART C - SHORT ANSWER	15	
PART D – PROBLEMS	41	
Total	100	

PART A MULTIPLE CHOICE (KNOWLEDGE - 30)

Identify the letter of the choice that best completes the statement or answers the question.

1. Which of the following elements would have the lowest first ionization energy?

a. sodium
b. aluminum
c. nitrogen
d. chlorine
e. argon

2. Energy released when "excited" electrons return to lower energy levels produce...

a. electron affinities
b. ionization energies
c. line spectra
d. all of the above
e. none of the above

3. Which of the following is the electron configuration for neon?

a. $1s^2 2s^2 2p^4 3s^2$
b. $1s^1 2s^1 2p^6 3s^2$
c. $1s^2 2s^2 2p^6$
d. $1s^3 2s^3 2p^4$
e. $1s^2 2s^2 2p^8$

4. Iron forms a common ion with a charge of +3. The electron configuration of this ion is:

a. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5$
b. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^9$
c. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^8$
d. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6$
e. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^3$

5. Which of the following is true of orbitals?

a. They are two-dimensional paths around the nucleus.
b. They can contain maximum of two electrons.
c. Their shapes are predicted by Bohr's equation.
d. all of the above
e. none of the above

6. Which of the following is the electron configuration for the fluoride ion, F^-?

a. $1s^2 2s^2 2p^4$
b. $1s^2 1p^6$
c. $1s^2 2s^2 2p^5$
d. $1s^2 2s^2 2p^6$
e. $1s^2 2s^2 2p^6 3s^1$

7. In bonding orbital theory, a carbon-carbon triple bond consists of

a. 3 pi bonds
b. 1 sigma bond + 2 pi bonds
c. 2 sigma bond + 3 pi bonds
d. 1 sigma bonds + 4 pi bonds
e. 3 sigma bonds

8. A substance is a brittle crystal that conducts electricity in molten liquid state only. Which type of substance is it?

a. metallic crystal
b. ionic crystal
c. covalent crystal
d. molecular crystal
e. frozen gas

9. Four pairs of covalently-bonded electrons surrounding a central atom will be arranged

a. pyramidally
b. spherically
c. tetrahedrally
d. linearly
e. trigonally

10. The attractive forces that exist between atoms in liquid helium are known as

a. dipole-dipole forces
b. ion-dipole forces
c. covalent bonds
d. hydrogen bonds
e. Van der Waals forces

11. Which of these intermolecular forces exist in between water, H_2O, molecules:

I. Van der Waals
II. metallic bonding
III. hydrogen bonding
IV. covalent bonding

a. I only
b. I and IV only
c. I and III only
d. I, III and IV only
e. I, II and III only

12. The molar heat of vaporization of water is 42 kJ/mol. How much energy is released by the condensation of 3.0 g of water?

a. 0.88 kJ
b. 7.0 kJ
c. 130 kJ
d. 250 kJ
e. 0.07 kJ

13. When solid ammonium chloride, NH_4Cl, is added to water, the temperature of the solution decreases. Which statement best describes this observation?

a. The reaction is exothermic
b. Heat is released from the system, so it feels cooler.
c. $NH_4Cl_{(s)} \rightarrow NH_4Cl_{(aq)} + 33.6\ kJ$
d. $NH_4Cl_{(s)} \rightarrow NH_4Cl_{(aq)}\ \Delta H = +33.6\ kJ$
e. $NH_4Cl_{(s)} + H_2O_{(l)} \rightarrow NH_4Cl_{(aq)}\ \Delta S = -33.6\ kJ$

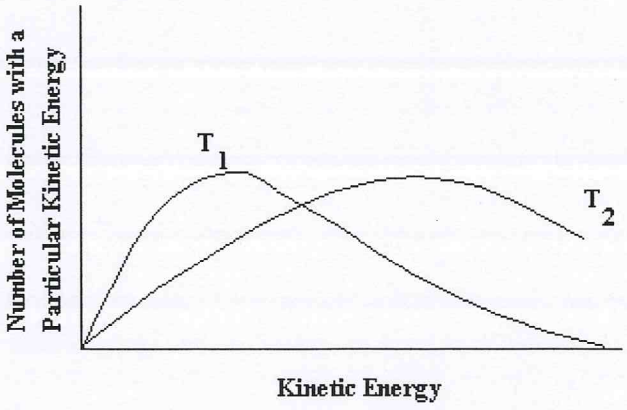
14. The presence of a catalyst is thought to increase the rate of a reaction by

a. changing the products that are formed in the reaction
b. decreasing the enthalpy change of the reaction
c. increasing the enthalpy change of the reaction
d. decreasing the activation energy of the reaction
e. increasing the activation energy of the reaction

15. In a saturated solution of lead(II) chloride, the concentration of chloride ion is 6.2×10^{-4} mol/L. The Ksp of lead(II) chloride would be which of the following?

a. 1.9×10^{-7}
b. 6.0×10^{-11}
c. 1.2×10^{-10}
d. 2.3×10^{-17}
e. none of the above

16. The following diagram represents a kinetic energy distribution at two temperatures.



In comparing the two temperatures, it is obvious that

a. $T_1 > T_2$
b. $T_2 > T_1$
c. $T_1 \propto T_2$
d. $T_1 = T_2$
e. cannot be determined

17. A full syringe contains this equilibrium:

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

brown gas *colourless gas*

Based on Le Chatelier's principle, what would be observed when the syringe is used to compress this gas mixture?

a. the mixture gets darker
b. the mixture gets darker then lighter
c. the mixture get lighter then darker
d. the mixture gets lighter
e. none of the above

18. The pH of a solution of HCl was found to be 3.4. The concentration of HCl of this solution (in mol/L) is which of the following?

a. 4.0×10^{-4}
b. 3.4
c. 0.29
d. 2.5×10^{-11}
e. 2.0×10^{-4}

19. The organic compound aniline ($C_6H_5NH_2$) acts as weak base. What is the chemical formula of aniline's conjugate acid?

a. C_6H_5COOH
b. $C_6H_5NH^-$
c. H_3O^+
d. OH^-
e. $C_6H_5NH_3^+$

20. Bronsted-Lowry defined a base as

a. a substance that releases H^+
b. a substance that releases OH^-
c. a proton donor
d. a proton acceptor
e. an electron pair acceptor

21. The oxidation number of chromium (Cr) in the dichromate ion ($Cr_2O_7^{2-}$) is

a. +2
b. +4
c. +6
d. +7
e. –2

22. An electrolytic cell transferred 0.35 mol of electrons when a current of 12 A was applied. How long in minutes did this take?

a. 17 min
b. 27 min
c. 53 min
d. 47 min
e. 0.78 min

23. Which substance in the following reaction has undergone reduction?

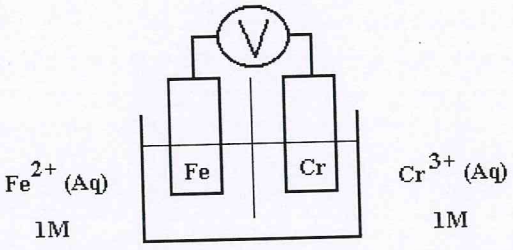
$$MnO_4^-{}_{(aq)} + 5\,C_2O_4^{2-}{}_{(aq)} + 16H^+{}_{(aq)} \rightarrow 2Mn^{2+}{}_{(aq)} + 10CO_{2(g)} + 8H_2O_{(l)}$$

a. MnO_4^-
b. $C_2O_4^{2-}$
c. H^+
d. Mn^{2+}
e. CO_2

24. Given the following half-cell reactions:

$Fe^{2+}{}_{(aq)} + 2e^- \rightarrow Fe_{(s)}$ $\quad E^o = -0.44$ V

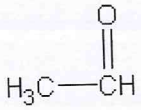
$Cr^{3+}{}_{(aq)} + 3e^- \rightarrow Cr_{(s)}$ $\quad E^0 = -0.74$ V



At 25°C, the initial cell voltage of the cell shown in the diagram above is

a. +1.18 V
b. −0.30 V
c. −1.18 V
d. +0.30 V
e. +1.34 V

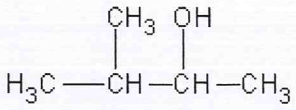
25.



The compound above is classified as a(n)

a. alcohol
b. carboxylic acid
c. aldehyde
d. ketone
e. alkene

26.



What is the correct name for the above compound?

a. 2-methyl-3-butanol
b. 2-pentanal
c. 1,2-dimethylpropanol
d. 3-methyl-2-butanal
e. 3-methyl-2-butanol

27.

i) 

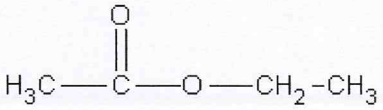
ii) 

The two substances shown above would best be described as:

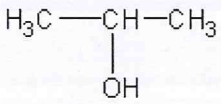
a. different compounds
b. structural isomers
c. geometric isomers
d. aliphatic hydrocarbons
e. aromatic hydrocarbons

28. The formula for methyl ethanoate is which of the following?

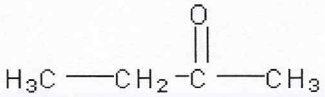
a.



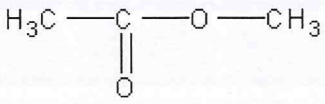
b.



c.



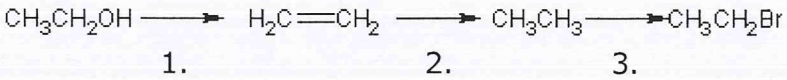
d.



29. Which of the following classes of organic compounds does not contain oxygen?

a. aldehydes
b. amines
c. amino acids
d. ethers
e. amides

30. The sequence of reactions shown here is best described as which of the following?



a. (1) Dehydration; (2)substitution; (3) hydrogenation
b. (1) Hydrogenation; (2) dehydration; (3) substitution
c. (1) Hydrogenation; (2) substitution; (3) dehydration
d. (1) Substitution; (2) hydrogenation; (3) dehydration
e. (1) Dehydration; (2) hydrogenation; (3) substitution

PART B: COMPLETION (KNOWLEDGE – 14)
Complete each sentence or statement.

1. The concept of the duality of matter means that an electron is both a particle and a wave.

2. The shape of boron trihydride, BH_3, is trigonal planar.

3. Due to its structure, diamond is classified as a network solid.

4. In an exothermic reaction, the potential energy of the products is less than the potential energy of the reactants.

5. $CO(g) + 2H_2(g) \rightarrow CH_3OH(l)$; during this reaction the entropy decreases.

6. A system at equilibrium always has forward and reverse reaction rates which are equal.

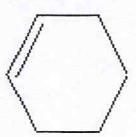
7. A solution at 25°C with a pOH of 3.45 has a pH of 10.55.

8. When nitric acid is titrated to an end point by lithium hydroxide, two products are lithium nitrate and water.

9. The standard reduction potential table lists the E° values of half-cell reactions measured in combination with the hydrogen standard half-cell.

11. Positively charged ions are called cations and migrate toward the cathode in an electrochemical or electrolytic cell.

12. Write the IUPAC name of the compound produced by this reaction:

 + Br_2 → 1,2-dibromocyclohexane.

Identify the missing element or particle in these nuclear reactions:

13. $^{60}_{26}Fe \rightarrow {}^{60}_{27}Co + \underline{\ {}^{0}_{-1}e\ }$

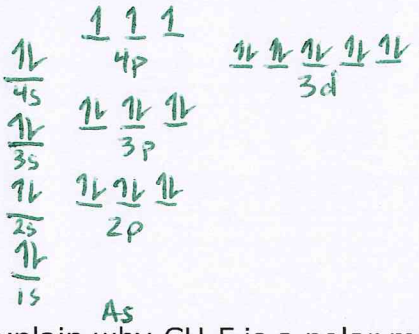
14. $\underline{\ {}^{235}_{92}U\ } + {}^{1}_{0}n \rightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3{}^{1}_{0}n$

} IGNORE

PART C: SHORT ANSWER (INQUIRY – 15)

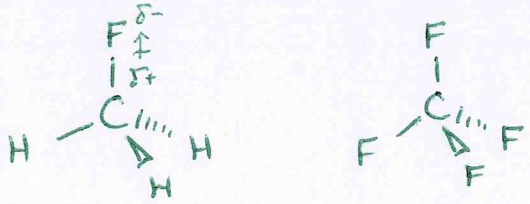
1. Draw an energy level diagram for arsenic, As.

2



2. Explain why CH_3F is a polar molecule while CF_4 is non-polar.

2



Due to symmetry of CF_4 and the fact that all bond dipoles are equivalent in magnitude they will cancel out thus the molecule is non-polar.

CH_3F has a molecular dipole toward the F atom therefore it is a polar substance.

3. Using Le Chatelier's principle, explain what effect, if any the following imposed changes will have on this equilibrium system.

$C_2H_4\,(g) + H_2\,(g) \rightleftharpoons C_2H_6\,(g) \quad \Delta H = -136.4$ kJ/mol

3

i) increase in temperature

SR: Equil shifts left $[C_2H_4]\uparrow\ [H_2]\uparrow\ [C_2H_6]\downarrow$

net result is same as the shift

ii) increase in pressure ← $V\downarrow \therefore C\uparrow$ initially

SR: Equil shifts right to produce less gas, $\downarrow P$ so $[C_2H_6]\uparrow\ [H_2]\downarrow\ [C_2H_4]\downarrow$

Net: $[C_2H_6]_{net}\uparrow\ [H_2]_{net}\uparrow$ (slightly) and $[C_2H_4]_{net}\uparrow$ (slightly)

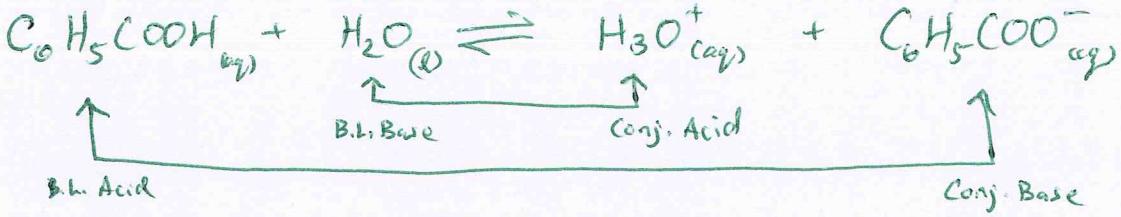
iii) increase in the concentration of ethane gas (C_2H_6)

SR: Equil shifts left $[C_2H_4]\uparrow\ [H_2]\uparrow\ [C_2H_6]\downarrow$

Net: $[C_2H_4]_{net}\uparrow\ [H_2]_{net}\uparrow\ [C_2H_6]_{net}\uparrow$ (slightly)

4. Write an equilibrium equation showing how benzoic acid (C_6H_5COOH) acts like a weak acid and identify both pairs of conjugate acid-base partners.

2

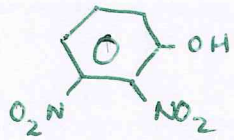


5. Draw the structures of the following organic compounds.

a) 2,3-dinitrophenol

b) methoxyethane

3

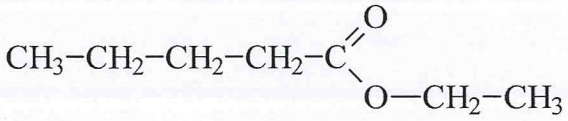


c) *cis*-2-hexene

6. Name the following organic compounds.

a)

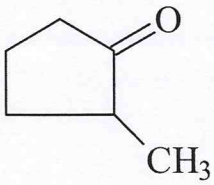
ethyl pentanoate



3

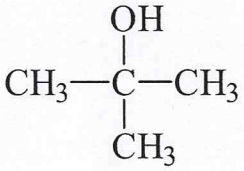
b)

2-methylcyclopentanone



c)

2-methyl-2-propanol



PART C: PROBLEMS

1. When 1.2 mol of H_2 and 2.4 mol of I_2 were placed in a 2.0 L container and allowed to reach equilibrium, the equilibrium concentration of HI was 0.40 mol/L. Calculate the equilibrium constant (K).

4

$$H_2 + I_2 \rightleftharpoons 2HI$$

	H_2	I_2	$2HI$
[I]	0.60	1.2	0
[C]	−0.20	−0.20	+0.40
[E]	0.40	1.0	0.40

$$K = \frac{[HI]^2}{[H_2][I_2]} = \frac{(0.40)^2}{(0.40)(1.0)} = 0.40$$

2. a) Calculate $\Delta H°$ (in kJ/mol) for the combustion of 1 mol of ethanol, $C_2H_5OH(l)$ with to form gaseous carbon dioxide and gaseous water using Hess's Law.

3

	ΔH_{form}
$C(s) + O_2(g) \longrightarrow CO_2(g)$	-393.5
$H_2(g) + \frac{1}{2} O_2(g) \longrightarrow H_2O(g)$	-241.8
$2C(s) + 3H_2(g) + \frac{1}{2} O_2(g) \longrightarrow C_2H_5OH(l)$	-235.2

TARGET: $C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$

$C_2H_5OH \rightarrow 2C + 3H_2 + \frac{1}{2}O_2$ $\quad \Delta H = 235.2$

$2C + 2O_2 \rightarrow 2CO_2$ $\quad \Delta H = (-393.5) \times 2$

$3H_2 + 2\frac{1}{2}O_2 \rightarrow 3H_2O(g)$ $\quad \Delta H = (-241.8) \times 3$

$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$ $\quad \Delta H_{rxn} = -1277.2$ kJ/mol C_2H_5OH

b) Based on your results from a), calculate the amount of energy released in the combustion of 500 g of ethanol.

2

$$\Delta H = \frac{q}{n} \qquad n = \frac{m}{M} = \frac{500\text{g}}{46.06\text{g/mol}} = 10.8554 \text{ mol}$$

$$q = \Delta H \cdot n = (1277.2)(10.8554) = 1.39 \times 10^4 \text{ kJ}$$

3. When sulfuric acid dissolves in water, a great deal of heat is given off. The enthalpy change for this process is called the enthalpy of solution. To measure it, 175 g of water was placed in a coffee-cup calorimeter and chilled to 10.0°C. Then 49.0 g of pure sulfuric acid ($H_2SO_4(l)$) also at 10.0°C, was added, and the mixture was quickly stirred with a thermometer. The temperature rose rapidly to 14.9°C. Calculate the energy released during the for the formation of this solution and the enthalpy of solution (in kilojoules per mole of H_2SO_4).

Assume that the mass of solution = mass water + sulfuric acid.
Assume that that the specific heat capacity of all solutions is 4.184 J/g°C.

* special case.

3

* normally considering water only →

$q = mc\Delta T$
$= (224)(4.184)(4.9)$
$= 4592.3584\ J$
$= 4.5923584\ kJ$

$n = \frac{m}{M} = \frac{49.0}{98.09} = 0.49954\ mol$

$\Delta H = \frac{-q}{n}$
$= \frac{-4.5923584\ kJ}{0.49954\ mol}$
$= -9.2\ kJ/mol$

4. Consider the following rate data for this reaction:

$$NO\ (g) + H_2\ (g) \longrightarrow HNO_2\ (g)$$

Experiment	NO (mol/L)	H_2 (mol/L)	Initial Rate of Reaction (mol/(L·s))
1	0.001	0.004	0.002
2	0.002	0.004	0.008
3	0.003	0.004	0.018
4	0.004	0.001	0.008
5	0.004	0.002	0.016
6	0.004	0.003	0.024

a) Determine the rate law equation for this reaction.

4

$[NO]$: $\frac{c_2}{c_1} = 2$, $\frac{r_2}{r_1} = 4$ $\therefore r \propto [NO]^2$

$[H_2]$: $\frac{c_5}{c_4} = 2$, $\frac{r_5}{r_4} = 2$ $\therefore r \propto [H_2]^1$

$\therefore r = k[NO]^2[H_2]$

b) Calculate the rate constant (k) using this data.

using Trial 1
$r = k[NO]^2[H_2]$
$0.002 = k(0.001)^2(0.004)$

$k = \frac{0.002}{(0.001)^2(0.004)}$
$= 5 \times 10^5$

c) What would the initial rate of reaction be if the concentration of both reactants were both 0.008 mol/L?

$r = k[NO]^2[H_2]$
$r = (5 \times 10^5)(0.008)^2(0.008)$
$r = 0.256\ \frac{mol}{L \cdot s}$

5. Calculate the mass of copper (I) sulfide that will completely dissolve in 1.0 L of water. The Ksp of Cu_2S is 6.0×10^{-37}.

4

$Cu_2S_{(s)} \rightleftharpoons 2Cu^+_{(aq)} + S^{2-}_{(aq)}$

if "x" than "2x" and "x"

$K_{sp} = [Cu^{2+}]^2[S^{2-}]$

$K_{sp} = (2x)^2(x)$

$6.0 \times 10^{-37} = 4x^3$

$x = 5.3 \times 10^{-13}$ mol/L

$n = cV$

$n = (5.3 \times 10^{-13})(1\ L)$

$n = 5.3 \times 10^{-13}$ mol

$m = n \cdot M$

$m = (5.3 \times 10^{-13})(159.17)$

$m = 8.4 \times 10^{-11}$ g

6. A piece of magnesium ribbon burns at a rate of 0.256 mol•s^{-1}. An equivalent amount of magnesium powder burns at a rate of 4.75 mol•s^{-1}. If the surface area of the magnesium ribbon 2.50 cm^2, what was the surface area of the magnesium powder?

2

$r_1 = 0.256$ mol/s

$r_2 = 4.75$ mol/s

$SA_1 = 2.50\ cm^2$

$SA_2 = ?$

$\frac{r_1}{r_2} = \frac{SA_1}{SA_2}$

$SA_2 = \frac{(2.50)(4.75)}{0.256}$

$SA_2 = 46.4\ cm^2$

7. What is the pH of a 0.500 mol/L solution of sodium cyanide (NaCN) if the cyanide ion has a $K_b = 1.61 \times 10^{-5}$? $NaCN \rightarrow Na^+ + CN^-$

4

	CN^-	+ H_2O ⇌	HCN	+ OH^-
[I]	0.500		0	0
[C]	$-x$		$+x$	$+x$
[E]	$0.500-x$		x	x

$K_b = \frac{[HCN][OH^-]}{[CN^-]}$

$K_b = \frac{x^2}{0.5-x}$

* Simplifying Assumption check

$\frac{0.5}{1.61 \times 10^{-5}} = 31055 > 100$

∴ assumption ok.

$1.61 \times 10^{-5} = \frac{x^2}{0.5}$

$x^2 = (0.5)(1.61 \times 10^{-5})$

$x = 2.84 \times 10^{-3}$ mol/L

$pOH = -\log[OH^-]$

$= -\log(2.837252 \times 10^{-3})$

$= 2.547$

∴ $pH = 14 - pOH$

$= 14 - 2.547$

$\boxed{pH = 11.453}$

8. Balance the following redox equation using the oxidation number method. Be sure to write and identify the oxidation and reduction reactions.

a) $\overset{+7\ -2}{MnO_4^-}_{(aq)} + \overset{-1}{Cl^-}_{(aq)} \longrightarrow \overset{+2}{Mn^{2+}}_{(aq)} + \overset{0}{Cl_2}_{(g)}$ (acidic solution)

4

red: $(\overset{+7}{Mn} + 5e^- \rightarrow \overset{+2}{Mn}) \times 2$

oxid: $(2\overset{-1}{Cl^-} \rightarrow Cl_2 + 2e^-) \times 5$

$2MnO_4^- + 10Cl^- + 16H^+ \longrightarrow 2Mn^{2+} + 5Cl_2 + 8H_2O$

b) $\overset{0}{Al}_{(s)} + \overset{+5\ -2}{NO_3^-}_{(aq)} \longrightarrow \overset{-3\ +1}{NH_3}_{(aq)} + \overset{+3\ -2}{AlO_2^-}_{(aq)}$ (basic solution)

red: $(\overset{+5}{N} + 8e^- \rightarrow \overset{-3}{N}) \times 3$

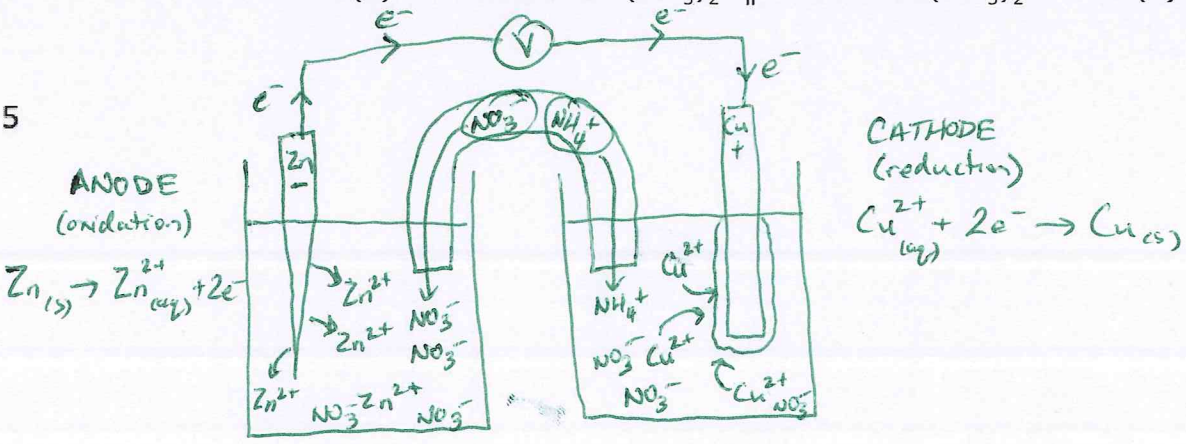
oxid: $(\overset{0}{Al} \longrightarrow \overset{+3}{Al} + 3e^-) \times 8$

$8Al + 3NO_3^- + 5OH^- + 2H_2O \rightarrow 3NH_3 + 8AlO_2^-$

9. a) Draw a diagram showing the following electrochemical cell. Label the anode, cathode, reduction half reaction, oxidation half reaction and direction of electron and ion movement. Include an ammonium nitrate salt bridge.

$Zn(s) \mid 0.005\ M\ Zn(NO_3)_2 \parallel 1.3\ M\ Cu(NO_3)_2 \mid Cu(s)$

5



b) What is the standard cell potential (E^o) of this cell?

$E^\circ_{cell} = 1.10\ V$

1

c) Calculate the actual cell potential (E) for this cell.

$E_{cell} = E^\circ_{cell} - \frac{0.05916}{n} \log K^*$

1

$E_{cell} = 1.10 - \frac{0.05916}{2} \log\left(\frac{0.005}{1.3}\right)$

$E_{cell} = 1.17\ V$

$Cu^{2+} + 2e^- \rightarrow Cu_{(s)}$

$Zn \rightarrow Zn^{2+} + 2e^-$

$Zn_{(s)} + Cu^{2+}_{(aq)} \rightarrow Cu_{(s)} + Zn^{2+}_{(aq)}$

$K^* = \frac{[Zn^{2+}]}{[Cu^{2+}]}$

10. Consider the following six substances:

$NaBr$ K C_4H_{10} Ne Si C_4H_9OH

The table below lists experimental data collected for six unknowns (A-F).

- Match each letter with the correct substance.
- For each, state the strongest type of attraction or bonding that accounts for these physical properties.

4

Letter	Melting Point (°C)	Boiling Point (°C)	Conductivity (as Solid)	Conductivity (as Liquid)
A	-138	-0.5	poor	poor
B	755	1390	poor	good
C	-249	-246	poor	poor
D	63	760	very good	very good
E	1414	2355	poor	poor
F	-89	117	poor	poor

Force to Overcome

B ⇒ NaBr – ionic ∴ conduct as liquid, high m.p + b.p. — ionic bonds.

D ⇒ K – metal ∴ conduct as solid + liquid — metallic bonds

A ⇒ C_4H_{10} – molecular (non-polar bonds) — Van der Waals
∴ low m.p/b.p
non-conductive

C ⇒ Ne – noble gas ∴ atomic solid extremely low m.p. — van der Waals

E ⇒ Si – metalloid ∴ covalent network high m.p/b.p — covalent bonds
likely not conductive due to covalent bonds

F ⇒ C_4H_9OH – molecular (polar bond with the OH) — Hydrogen bonding
∴ higher m.p./b.p. than non-polar subs.
non-conductive