Diploma of Health Sciences

Diploma of Science

**SLE155 Chemistry for the Professional Sciences**

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| **This is NOT a practice exam.**  **The following are a wide range of questions to practise.**  **The solutions will be discussed in your week revision classes**  **Your final exam will be 2 hours.**  **It will have 10 questions and be out of a total of 80 marks.**  **It will be worth 40% of your final mark for Chemistry for the Professional Sciences.**  **Also check the exam information on Moodle under week 13 for the data sheets which you will be given with your final examination.** |

**Q1 Chemical reactions and stoichiometry**

a) For the following balanced equations write a **net ionic equation**.  
Make sure that you include **states** in your final **net ionic equation**.

[3 marks]

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| 2 NaHCO3(aq) + H2SO4(aq) → Na2SO4(aq) + 2 H2O(l) + 2 CO2(l) |
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| 2 KOH(aq) + SnCl2(aq) → Sn(OH)2(s) + 2 KCl(aq) |
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| 2 Cr(NO3)3 (aq) + 3 Na2S (aq) → Cr2S3 (s) + 6 NaNO3 (aq) |
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b) Propane (C3H8) burns in oxygen to produce carbon dioxide and water.

C3H8(g) + 5O2(g) → 3CO2(g) + 4H2O(g)

Suppose that 0.3818 moles of C3H8 and 1.718 moles of O2 are allowed to react and this is the only reaction that occurs. Calculate the mass of carbon dioxide that can be formed from this mixture of reactants.

[5 marks]

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**Q1 Chemical reactions and stoichiometry**

c) 66.7 mL of 18.0 molar sulfuric acid solution was dissolved in enough water to make 500.0 mL of solution. Calculate the molarity of the diluted mixture.

[2 marks]

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d) What volume in mL of 0.446 M KMnO4(aq) are required to react with 50.0 mL of 0.200 M H2C2O4(aq) in the presence of excess H2SO4(aq)? The reaction is:

2KMnO4(aq) + 5H2C2O4(aq) + 3H2SO4(aq) → 2MnSO4(aq) + 10CO2(g) + 8H2O(l) + K2SO4(aq)

[3 marks]

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**Q1 Chemical reactions and stoichiometry**

e) The reaction of powdered aluminium and iron(III) oxide :

2 Al + Fe2O3 → Al2O3 + 2 Fe

produces so much heat that the iron that forms is molten. Because of this, the railways use the reaction when laying track to provide molten steel to weld the rails together. Suppose that, in one batch of reactants, 140.3 g of Al was mixed with 278.2 g of Fe2O3. Calculate the mass of iron that can be formed from this mixture of reactants.

[4 marks]

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f) What volume of 0.140 M Ca(NO3)2(aq) solution is needed to react completely with   
25.0 mL of 0.185 M Na3PO4(aq) solution to give a precipitate of Ca3(PO4)2?

2 Na3PO4(aq) + 3 Ca(NO3)2(aq) → Ca3(PO4)2(s) + 6 NaNO3(aq)

[3 marks]

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**Chemical bonding and molecular structure**

a) Write the Lewis structures for the following molecules:

SF4

CH3Cl

State if each molecule would be polar or non-polar and give your reasons.

[2 × 2 = 4 marks]

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| SF4 | CH3Cl |

b) Both PF3 and PF5 are known compounds. NF3 also exists, but NF5 does not. Explain why there is no molecule with the formula NF5.

[2 marks]

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**Chemical bonding and molecular structure**

c) i) Draw the Lewis structure for IF3  
ii) Name the geometry of the electron pairs (do not draw)

iii) Draw the shape of the molecule indicating polar bonds with δ+ and δ–

iv) Name the shape of the molecule

v) Indicate if the molecule overall is polar or non-polar. Explain.

[2 + 1 + 2 + 1 + 2 = 8 marks]

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| i) Lewis structure drawing | iii) Molecular shape drawing |
| ii) **Electron pair geometry** name | iv) Name of **shape of molecule** |
| v) Polar or non-polar? Explain | |

d) Draw the shapes of the NH3 and H2O molecules, then briefly explain why the bond angles are less than the ideal 109.5°.

[3 marks]

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**Chemical bonding and molecular structure**

e) Which is the shorter bond length, C – N or C – C?

Explain the factors that influenced your choice.

[2 marks]

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f) Predict the hybridisation (sp, sp2 or sp3) and bond angle of the indicated atoms.

[6 × ½ = 3 marks]

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|  | Atom a)  Atom b) |
|  | Atom a)  Atom b) |
|  | Atom a)  Atom b) |

**Chemical Equilibrium**

a) i) Write the equilibrium constant expression, *K*c, for each of the following reactions in terms of their molar concentrations.

[1 mark]

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| 2NaHSO3(s)  Na2SO3(s) + H2O(g) + SO2(g) |  |

ii) Arrange the reactions below in order of their increasing tendency to go towards completion.

[1 mark]

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| 2CH4(g)  C2H6(g) + H2(g) | *Kc* = 9.5 × 1013 | Eqn 1 |
| CH3OH(g) + H2(g)  CH4(g) + H2O(g) | *Kc* = 3.6 × 1020 | Eqn 2 |
| H2(g) + Br2(g)  2HBr(g) | *Kc* = 2.0 × 109 | Eqn 3 |
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b) Consider the reaction:

N2O(g) + NO2(g)  3NO(g) Δ*H*° = + 155.7 kJ mol–1

In which direction will this equilibrium be shifted by the following changes?

i) Adding N2O(g)

[1 mark]

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(ii) Increasing the temperature of the reaction mixture

[1 mark]

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iii) Addition of helium to the reaction mixture at constant volume

[1 mark]

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**Chemical Equilibrium**

c) At 460 °C, the reaction:

SO2(g) + NO2(g)  NO(g) + SO3(g) has *K*c = 85.0

A reaction flask at 460 °C contains these gases at the following concentrations:

[SO2] = 0.00250 mol L–1 [NO2] = 0.00350 mol L–1

[NO] = 0.0250 mol L–1 [SO3] = 0.0400 mol L–1

i) State if the reaction mixture is at equilibrium. Show briefly how you arrived at your conclusion.

[3 marks]

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c) ii) If the reaction above is not at equilibrium, predict in which direction a spontaneous change would occur to get to equilibrium. Explain briefly how you arrived at your conclusion.

[2 marks]

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**Chemical Equilibrium**

d) Water dissociates to a very small amount into oxygen and hydrogen at high temperatures as in the equation below:

2 H2O(g )  2 H2(g) + O2(g)

The value of *K*c is 5.4 × 10–5 for the reaction at a temperature of 3290 K.

If a reaction vessel initially contains 0.500 mol L–1 H2O (g), **calculate** the equilibrium concentrations of H2 and O2  at 3290 K.

[4 marks]

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**e)** A student prepared a buffer solution made up of NH3 and NH4Cl. Determine the pH of the buffer when [NH3] = 0.25 mol L–1 and [NH4Cl] = 0.45 mol L–1.

Ammonium ion has a *K*a of 5.56 × 10–10and a p*K*a of 9.26.

[3 marks]

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**Solutions and solubility**

a) i) Write the equation, including states, for the dissolution of calcium fluoride, CaF2.

[1 mark]

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ii) Write the expression for the solubility product, Ksp, for calcium fluoride.

[1 mark]

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b) The solubility product of lead(II) sulfate, PbSO4, at 25 °C is 6.3 × 10–7. Calculate the molar solubility of lead(II) sulfate at this temperature.  
Hint: Assume that S mole of lead(II) sulfate dissociates into lead(II) ions and sulfate ions.  
 [3 marks]

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c) i) Define what is meant by the term “molality”

[1 mark]

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**Solutions and solubility**

c) (ii) Benzene, C6H6, and water, H2O, are immiscible. Explain briefly what this means. Also explain why they are immiscible in terms of the structures of the molecules and the forces of attraction between them.

[2 marks]

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d) Calculate the mass of sodium chloride, NaCl, (a salt found in seawater) which would have to be dissolved in 500 g of water to give a solution of molality   
0.150 mol kg–1.

[2 marks]

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e) Explain why the vapour pressure of a solvent above a solution is less than that above the pure solvent at the same temperature.

[2 marks]

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**Oxidation and reduction**

a) i) Assign oxidation numbers to all of the atoms in the following compounds or ions:

[2 marks]

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| Cr2O72– | **Atom** | **Oxidation number** | **Atom** | **Oxidation number** |
| **Cr** |  | **O** |  |
| MnO2 | **Atom** | **Oxidation number** | **Atom** | **Oxidation number** |
| **Mn** |  | **O** |  |

ii) Balance the following half equation for reaction occurring in acidic solution.

NO3–(aq) → NH4+(aq)

Show your working. Indicate whether the reaction is oxidation or reduction.

[2 marks]

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iii) Balance the following half equation for reaction occurring in basic solution.

H4IO6–(aq) → I2(s)

Show your working. Indicate whether the reaction is oxidation or reduction.

[3 marks]

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**Oxidation and reduction**

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| Au3+(aq)|Au(s) | Fe3+(aq)|Fe2+(aq) | Cd2+(aq)|Cd(s) | Fe2+(aq)|Fe(s) | Zn2+(aq)|Zn(s) |
| +1.42 V | +0.77 V | –0.40 V | –0.44 V | –0.76 V |

b) i) Use the data in the table above to calculate the standard cell potential for the following reaction at 25 °C.

Cd2+(aq) + Fe(s) → Cd(s) + Fe2+(aq)

[1 mark]

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c) i) For the following reaction, identify the substance being oxidised, and the substance being reduced.   
Assign oxidation numbers to the atoms being oxidised and/or reduced.

4 Au + 16 CN– + 3 O2 + 6 H2O → 4 [Au(CN)4]– + 12 OH–

[2 marks]

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| Substance oxidised | Substance reduced |
| Oxidation number of atoms being oxidised on each side of the equation | Oxidation number of atoms being reduced on each side of the equation |

ii) Balance the following half equation for reaction occurring in acidic solution.

BiO3–(aq) → Bi3+(aq)

Show your working. Indicate whether the reaction is oxidation or reduction.

[2 marks]

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**Oxidation and reduction**

iii) Balance the following half equation for reaction occurring in basic solution.

SO2Cl2(l) → SO32–(aq) + Cl–(aq)

Show your working. Indicate whether the reaction is oxidation or reduction.

[3 marks]

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iv) Using half-reactions and showing your working, balance the following equation in basic solution.

BH4–(aq) + MnO4–(aq) → H2BO3–(aq) + MnO2(s)

Show your working. Indicate whether each half reaction is oxidation or reduction.

[5 marks]

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