UNIVERSITEIT VAN PRETORIA
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YUNIBESITHI YA PRETORIA

DEPARTEMENT CHEMIE
DEPARTMENT OF CHEMISTRY

CMY 117
SEMESTERTOETS 3 / *SEMESTER TEST 3*

DATUM / DATE:	12 May 2008	**EKSAMINATORE/ EXAMINERS:**	Prof. WJ Schoeman Dr JB Laurens Mrs AC Botha
TYD / TIME:	2 ure / hours		
PUNTE / MARKS:	100	**EKSTERN / EXTERNAL:**	Dr EMM Venter

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VAN EN VOORLETTERS: _____
SURNAME AND INITIALS:

Afdeling B / Section B

1	E
2	A
3	E
4	C
5	C
6	A
7	C
8	E
9	C
10	B
11	D
12	D
13	B
14	C
15	A
16	C
17	C
18	C
19	E
20	B

Afdeling A / Section A

Vraag 1 Konsentrasie en Verdunning
Question 1: Concentration and Dilution [7]

[5]

1.1 8.5 g van 'n onsuiwer monster wat 95% natrium chromaat bevat word in gedistilleerde water opgelos om 500.0 cm^3 oplossing te maak. Bereken die volume van hierdie oplossing (in cm^3) wat benodig word 2.5 dm^3 oplossing te maak waarin $[Na^+] = 0.0034$ $mol{\cdot}dm^{-3}$. (Neem aan dat die onsuiwerhede nie natrium ione bevat nie)

A 8.5 g impure sample containing 95% sodium chromate is dissolved in distilled water to make 500.0 cm^3 solution. Calculate the volume of this solution (in cm^3) needed to make 2.5 dm^3 solution in which $[Na^+] = 0.0034$ $mol{\cdot}dm^{-3}$? (Assume that none of the impurities contain sodium ions)

[7]

Mass of sodium chromate in the sample:

$$8.5\ g \times \frac{95}{100} = 8.075\ g\ Na_2CrO_4$$

Moles of sodium chromate:

Molar mass of sodium chromate = 161.98 g

$$8.075\ g \times \frac{1\ mol}{161.98\ g} = 0.0499\ mol$$

Molar concentration of the original sodium chromate solution:

$$C = \frac{n}{V} = \frac{0.0499\ mol}{0.5000\ L} = 0.0997\ M$$

Sodium ion concentration in the original solution:

Each mol sodium chromate produces two moles of sodium ions in solution

$[Na^+] = 2 \times 0.0997 = 0.1994$ M

Moles of Na^+ required to make the 2.5 dm^3 solution:

$2.5\ dm^3 \times 0.0034\ mol{\cdot}dm^{-3} = 8.5 \times 10^{-3}$ mol Na^+

Volume of the original solution which contains the calculated amount of Na^+:

$$V = \frac{n}{C} = \frac{8.5 \times 10^{-3}\ mol}{0.1994\ mol \cdot dm^{-3}} = 0.0426\ dm^3 = 43\ cm^3$$ *(2 significant figures)*

Alternative method: Dimensional analysis

$$2.5\ L\ dil\ soln \times \frac{0.0034\ mol\ Na^+}{1\ L\ dil\ soln} \times \frac{1\ mol\ Na_2CrO_4}{2\ mol\ Na^+} \times \frac{161.98\ g\ Na_2CrO_4}{1\ mol\ Na_2CrO_4} \times \frac{100\ g\ sample}{95\ g\ Na_2CrO_4} \times \frac{500.0\ cm^3}{8.5\ g\ sample} = 43\ cm^3$$

[5]

Vraag 2 Redoksreaksie
Question 2: Redox reaction [7]

Suurstof word tydens die reaksie van permanganaat soute met waterstofperoksied in verdunde swaelsuuroplossing geproduseer:

Oxygen is produced from the reaction of permanganate salts with hydrogen peroxide in a dilute sulphuric acid solution:

$$KMnO_4 + H_2O_2 + H_2SO_4 \rightarrow Mn^{2+} + O_2$$

Balanseer hierdie redoksreaksievergelyking met die half-reaksie metode en gee die molekulêre vergelyking . Gee die half-reaksies en alle stappe duidelik weer. Gee ook al die oksidasiegetalle.

Balance this redox reaction equation by the half-reaction method and write the molecular equation. Write the half reactions and clearly indicate all steps. Also give all the oxidation numbers.

[7]

Determine the oxidation states:

Reduction

+1 +7 -2 +1 -1 +1 +6 -2 +2 0

$KMnO_4 + H_2O_2 + H_2SO_4 \rightarrow Mn^{2+} + O_2$

Oxidation

Write the reduction and oxidation half-reactions and balance the O, H and charge:

Reduction $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$

Oxidation $H_2O_2 \rightarrow O_2 + 2H^+ + 2e^-$

Multiply each half-reaction to make the number of electrons equal:

Reduction $2MnO_4^- + 16H^+ + 10e^- \rightarrow 2Mn^{2+} + 8H_2O$ [×2]

Oxidation $5H_2O_2 \rightarrow 5O_2 + 10H^+ + 10e^-$ [×5]

Simplify and add:

$2MnO_4^- + 5H_2O_2 + 6H^+ \rightarrow 2Mn^{2+} + 5O_2 + 8H_2O$

Add the spectator ions and phase to complete the molecular equation:

$2KMnO_4(aq) + 5H_2O_2(aq) + 3H_2SO_4(aq) \rightarrow 2MnSO_4(aq) + 5O_2(g) + 8H_2O(l) + K_2SO_4(aq)$

Question 3: Titration (using *data in English version) [7]

The iron content in an ore sample is determined by first dissolving the ore in hydrochloric acid, and then titrating the solution with $KMnO_4$:

$$5Fe^{2+}(aq) + MnO_4^-(aq) + 8H^+(aq) \rightarrow 5Fe^{3+}(aq) + Mn^{2+}(aq) + 4H_2O(\ell)$$

3.1 A sample of ore of mass 0.202 g needed 16.7 cm^3 of *0.0108 mol dm^{-3} $KMnO_4$ to reach the stoichiometric point. What mass of iron(II) ions is present in the sample?

*This value differs from the value given in the Afrikaans version of this question [5]

Dimensional analysis method:

$$0.0167\ L \times \frac{0.0108\ mol\ MnO_4^-}{1\ L} \times \frac{5\ mol\ Fe^{2+}}{1\ mol\ MnO_4^-} \times \frac{55.85\ g}{1\ mol} = 0.0504\ g\ Fe^{2+}$$ *(3 significant figures)*

Or

Moles of MnO_4^-:
16.7 cm^3 is 0.0167 dm^3
$n = C \times V = 0.0108 \times 0.0167 = 1.804 \times 10^{-4}$ mol

Moles of Fe^{2+} present in the acid solution:
$1.804 \times 10^{-4} \times 5 = 9.018 \times 10^{-4}$ mol Fe^{2+}

Mass of Fe^{2+}:
Molar mass of Fe^{2+} = 55.85 g/mol
9.018×10^{-4} mol × 55.85 g/mol = 0.0504 g *(3 significant figures)*

3.2 What is the mass percentage of iron in the ore sample?

[2]

$$\text{Mass percentage iron} = \frac{\text{mass of iron}}{\text{mass of ore}} \times 100\% = \frac{0.0504\ g}{0.202\ g} \times 100\% = 25.0\%$$ *(3 significant figures)*

[5]

Vraag 3 Titrasie (gebruik *data in Afrikaanse weergawe) [7]

Die ysterinhoud van 'n ertsmonster word bepaal deur die erts eers in soutsuur op te los en dan met $KMnO_4$ te titreer.

$$5Fe^{2+}(aq) + MnO_4^-(aq) + 8H^+(aq) \rightarrow 5Fe^{3+}(aq) + Mn^{2+}(aq) + 4H_2O(\ell)$$

3.1 'n Ertsmonster van 0.202 g benodig 16.7 cm^3 van *0.108 mol·dm^{-3} $KMnO_4$ om die stoïgiometriese punt te bereik. Watter massa yster(II) ione is teenwoordig in die monster?

*Die waarde verskil van die waarde in die Engelse weergawe van hierdie vraag [5]

Omsettingsfaktoremetode:

$$0.0167\ L \times \frac{0.108\ mol\ MnO_4^-}{1\ L} \times \frac{5\ mol\ Fe^{2+}}{1\ mol\ MnO_4^-} \times \frac{55.85\ g}{1\ mol} = 0.504\ g\ Fe^{2+}$$ *(3 beduidende syfers)*

Or

Mol MnO_4^-:
16.7 cm^3 is 0.0167 dm^3
$n = C \times V = 0.108 \times 0.0167 = 1.804 \times 10^{-3}$ mol

Mol Fe^{2+} teenwoordig in die suuroplossing:
$1.804 \times 10^{-3} \times 5 = 9.018 \times 10^{-3}$ mol Fe^{2+}

Massa Fe^{2+}:
Molêre massa van Fe^{2+} = 55.85 g/mol
9.018×10^{-3} mol × 55.85 g/mol = 0.504 g *(3 beduidende syfers)*

3.2 Wat is die massapersentasie yster in die ertsmonster?

[2]

$$\text{massapersentasie yster} = \frac{\text{massa yster}}{\text{massa erts}} \times 100\% = \frac{0.504\ g}{0.202\ g} \times 100\% = 250.\%$$ *(3 beduidende syfers)*

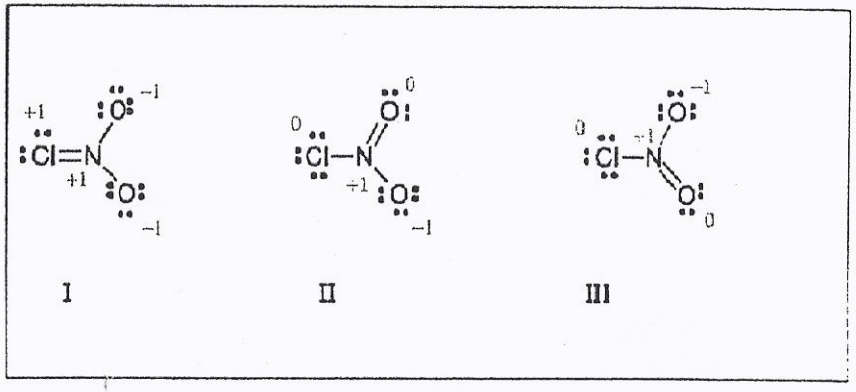
[8]

Vraag 4 Chemiese Binding en Molekulêre Struktuur
Question 4: Chemical Bonding and Molecular Geometry [14]

4.1 Teken Lewisstrukture van drie resonansstrukture van nitrielchloried, $ClNO_2$, waar stikstof die sentrale atoom is. U mag die bindingselektrone met simbole of strepies aandui. Alle alleenpare moet aangedui word.

Write three resonance structures for nitryl chloride, $ClNO_2$, in which nitrogen is the central atom. You may indicate the bonding electrons with symbols or lines. All lone pairs must be included.

[6]



4.2 Ken formele ladings toe aan al die atome in die resonansstrukture in 4.1. Skryf dit by die atome in die strukture in 4.1 hierbo.

Voorspel watter struktuur/strukture verkies sal word. Motiveer jou voorspelling.

Assign formal charges to all the atoms in the resonance structures in 4.1. Write them next to the atoms in the structures in 4.1 above.

Predict which structure(s) is (are) preferred. Motivate your prediction.

[3]

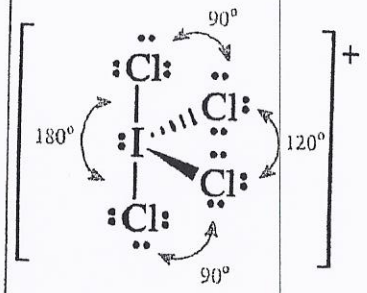
Formal charges on atoms in the three structures above

Structure I will not exist (fewer atoms with 0 formal charge when compared to other structures).
There will be resonance between structures II and III since they both have 2 atoms with zero (0) formal charge (and the negative formal charge is on the more electronegative atom, O, in both).

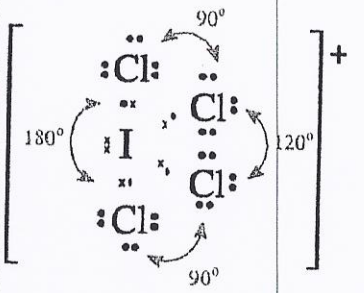
4.3 Gebruik die VSEPR model om die molekulêre geometrie van ICl_4^+ te voorspel. Teken die Lewisstruktuur van hierdie poli-atomiese ioon en dui die grootte van al die bindingshoeke aan in jou skets. U mag die bindingselektrone met simbole of strepies aandui. Alle alleenpare moet aangedui word.

Use the VSEPR model to predict the molecular geometry of ICl_4^+. Draw the Lewis structure of this polyatomic ion and indicate the sizes of all the bond angles in your drawing. You may indicate the bonding electrons with symbols or lines. All lone pairs must be included.

[5]



Or/Of



Molekulêre geometrie: versteurde tetrahedron; wip-plank
Molecular geometry: see-saw

[10]

Vraag 5 Chemiese Ewewig
Question 5: Chemical Equilibrium

[12]

Beskou die volgende ewewig:

Consider the following equilibrium:

$$A(g) + B(g) + X(s) \rightleftharpoons 2Y(g) \qquad \Delta H^\circ \text{ is negatief / negative}$$

5.1 By 150°C is $K_c = 25$. Die volgende hoeveelhede is teenwoordig in 'n 1.00 L houer by ewewig:

A	0.50 mol
B	0.50 mol
X	1.00 mol

Wat is die ewewig **konsentrasie** van Y?

At 150°C $K_c = 25$. At equilibrium there are the following amounts in the 1.00 L container:

A	0.50 mol
B	0.50 mol
X	1.00 mol

What is the equilibrium **concentration** of Y?

[3]

$$K_c = \frac{[D]^2}{[A][B]} = 25$$

$$[D]^2 = 25 \times 0.50 \times 0.50 = 6.25$$

$$[D] = 2.5\ M$$

5.2 Voorspel wat sal gebeur, asook die invloed op die waarde van K_c indien die reaksiemengsel verhit word.

Predict what will happen and the effect on the value of K_c if the reaction mixture is heated.

[2]

[The forward reaction is exothermic (negative ΔH value) and the reverse reaction endothermic.]

Wanneer dit verhit word sal die reaksie in die rigting wat hitte absorbeer verplaas word – dit is die endoterme reaksie.
M.a.w. die tempo van die hierdie reaksie word na links verplaas totdat ewewig bereik word by die nuwe temperatuur.

When heated the reaction will shift in the direction that will consume heat, which is the endothermic reaction.

So this reaction will shift left until equilibrium is established at the new temperature.

5.3 1.00 mol van Y word by die ewewigmengsel by 150°C in 5.1 gevoeg. Wat sal die konsentrasies van reagense en produk wees wanneer die ewewig herstel is?

1.00 mol of Y is added to the equilibrium mixture in 5.1 at 150°C. What will the concentrations of reactants and product be when equilibrium is re-established?

[7]

When more Y is added to the mixture the rate of the reverse reaction will increase – reactants will increase while product will decrease. Let the increase in A be x M.

(Indien meer Y by die mengsel gevoeg word, sal die tempo van die terugwaartse reaksie toeneem – reagense sal vermeerder terwyl produk sal verminder. Stel die toename in A is x M)

	A(g)	+	B(g)	+	X(s)	⇌	2Y(g)
Initial	0.50 M		0.50 M		-		**3.5 M**
Change	+x		+x				-2x
Equilibrium	(0.50+x) M		(0.50+x) M				(3.5-2x) M

$$K_c = \frac{(3.5-2x)^2}{(0.50+x)^2} = 25$$

$$\frac{3.5-2x}{0.50+x} = 5$$

$$7x = 1.0$$

$$x = 0.14 \text{ M}$$

$[A] = [B] = 0.64$ M

$[D] = 3.5 - 0.28 = 3.2$ M

[13]

Vraag 6 Sure en Basisse
Question 6: Acids and Bases

[13]

6.1 Die pH van 'n 0.100 M $HClO_2$ oplossing is 1.57 by 25°C. Bereken die pK_a van chlorigsuur by 25°C.

The pH of a 0.100 M $HClO_2$ solution is 1.57 at 25°C. Calculate the pK_a of chlorous acid at 25°C.

[6]

$[H_3O^+] = 10^{-pH} = 10^{-1.57} = 0.027$ M Dit is $[H_3O^+]$ by ewewig (at equilibrium)

	$HClO_2$	+	H_2O	⇌	ClO_2^-	+	H_3O^+
Aanvanklik	0.100 M		-		0		0
Verandering	-0.027 M		-		+0.027 M		+0.027 M
Ewewig	0.073 M		-		0.027 M		0.027 M

$$K_a = \frac{[ClO_2^-][H_3O^+]}{[HClO_2]} = \frac{0.027^2}{0.073} = 1.0\times10^{-2} \qquad pK_a = -\log K_a = 2$$

6.2 Bereken die pH van 'n 0.26 M metielamien, CH_3NH_2, oplossing by 25°C.

Calculate the pH of a 0.26 M methylamine, CH_3NH_2, solution at 25°C.

[7]

	CH_3NH_2	+	H_2O	⇌	$CH_3NH_3^+$	+	OH^-
Initial	0.26 M		-		0		0
Change	-x M		-		+x M		+x M
Equilibrium	(0.26 – x) M		-		x M		x M

$K_b = 4.4\times10^{-4}$

Since $x \ll 0.26$, $(0.26 - x) \approx 0.26$ (Very small value of K_b)

$$K_b = \frac{[CH_3NH_3^+][OH^-]}{[CH_3NH_2]} = \frac{x^2}{0.26} = 4.4\times10^{-4}$$

$$x^2 = 1.144\times10^{-4}$$

$$x = 0.011$$

$[OH^-] = 0.011$ M (4.2% ionization – approximation is valid)

$pOH = -\log[OH^-] = -\log 0.011 = 1.97$

$pH = 14 - pOH = 14 - 1.97 = 12$

or $[H_3O^+] = 10^{-14} / [OH^-] = 10^{-14} / 0.011 = 9.1\times10^{-13}$ M

$pH = -\log[H_3O^+] = -\log(9.1\times10^{-13}) = 12$