NORTH-WEST UNIVERSITY
YUNIBESITI YA BOKONE-BOPHIRIMA
NOORDWES-UNIVERSITEIT

Modulekode:	CHEM111	Metode van aflewering:	Voltyds			Datum:	11/07/2017
Tipe assessering:	Eksamen 2de geleentheid	Vraestelnommer:	2	Sessie:	09:00	Tydsduur:	3 uur

Modulebeskrywing: **Inleidende Anorganiese en Fisiese Chemie**	Lokaal:

Afrolmetode:

(1) **Gekombineerde** Afrikaans/Engelse vraestel		(2) Vraestel vir 'n **spesifieke taal**			
Aantal studente:	Ja		Afrikaans	Engels	Ander taal
		Aantal studente:	0	0	0

Benodighede vir vraestel		Aantal per student	**Benodighede** vir vraestel		Aantal per student
Antwoordskrifte			Multikeuse-kaarte (A5 – 40 vrae)		
Presensiestrokies vir invulvraestel	X	1	Multikeuse-kaarte (A4 – 115 vrae)		
Rofwerkpapier			Grafiekpapier		

Is daar 'n **bylaag** aangeheg?	Nee	Indien **Ja** gee 'n kort beskrywing:	**Geen bylaag, maar die studente mag bladsye 18 tot 23 van die vraestel afskeur vir gebruik tydens die vraestel. Hulle mag die afgeskeurde bladsye NIE inhandig nie. Dit moet weggegooi word.**

NB: Eksamenafdeling doen geen kontrole wat inhoud of bladsynommers van bylae betref nie.

Sakrekenaars: Ja

Ander hulpmiddels bv. woordeboeke, studiegidse, ens.:

Inhandiging van antwoordskrifte:	Gewoon
Indien **Per dosent, lys Vanne:**	

Eksaminator(e):

(1) **Dr C.E. Read** Bylyn: **992351**

Selfoonnr: **082 567 5545** Handtekening

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Moderator:

Dr C.G.C.E. van Sittert Bylyn: **992338**

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Universiteitsnommer:

Eksterne Moderator:

Selfoonnr:

Ingehandig deur:

Dr C.E. Read Universiteitsnommer: Bylyn: **992351**

Verwysingsnommer: 7.1.9.3.

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Benodigdhede vir hierdie vraestel/Requirements for this paper:

Antwoordskrifte/ Answer scripts:	☐	Multikeusekaarte (A5)/ Multi-choice cards (A5):	☐
Presensiestrokies (Invulvraestel)/ Attendance slips (Fill-in paper):	☒	Multikeusekaarte (A4)/ Multi-choice cards (A4):	☐
Rofwerkpapier/ Scrap paper:	☐	Grafiekpapier/ Graph paper:	☐

Sakrekenaars/Calculators: **Ja/Yes**

Ander hulpmiddels/Other resources:

'n Nie-programeerbare sakrekenaar.
A non programmable calculator.

Tipe Assessering/ Type of Assessment:	**Eksamen 2e geleentheid Exam 2nd opportunity Vraestel/Paper 2**	Kwalifikasie/ Qualification:	**B.Sc./B.Pharm./ B.Ing.**
Modulekode/ Module code:	**CHEM111**	Tydsduur/ Duration:	**3 uur 3 hour**
Module beskrywing/ Module description:	**Inleidende Anorganiese en Fisiese Chemie**	Maks/ Max:	**102**
Eksaminator(e)/ Examiner(s):	**Dr C.E. Read**	Datum/ Date:	**11/07/2017**
	Mev M.H. du Toit	Tyd/ Time:	**09:00**
Moderator(s):	**Dr C.G.C.E. van Sittert**		

Inhandiging van antwoordskrifte/Submission of answer scripts: **Gewoon/Ordinary**

Titel:
Title: ____________

Van:
Surname: MEMORANDUM

Volle voorletters:
Full initials: ____________

Universiteitsnommer:
University number: ____________

Eksamenvoorskrifte / Examination instructions

1. Studente mag in die eerste halfuur van 'n sessie tot die lokaal toegelaat word, maar geen ekstra tyd word toegestaan nie.
2. Geen student word toegelaat om die lokaal te verlaat binne die eerste halfuur van 'n eksamensessie nie.
3. Studente bring sakke na lokaal op **eie risiko**, en moet dit voor in die lokaal neersit.
4. Studente mag nie selfone/elektroniese toestelle by hulle hê en/of hanteer nie.
5. Geen verversings word in 'n eksamenlokaal toegelaat nie.
6. Studente mag nie die lokaal verlaat om te gaan rook nie.
7. Skryf op beide kante van die bladsye.
8. Skryf slegs in swart of blou ink.
9. Geen bladsye mag uit die antwoordskrif verwyder word nie.
10. Studente mag nie ontoelaatbare materiaal by hulle hê tydens 'n sessie nie, bv. notas en/of objekte wat notas bevat nie.
11. Geen items mag tydens die sessie geleen word nie.
12. Studente mag nie 'n ander student probeer help of probeer om hulp te kry nie.
13. Studente **moet** hul antwoordskrifte aan toesighouers oorhandig voordat hulle die lokaal verlaat.
14. Die presensiestrokie op die agterblad, wat ook as onderneming geld, **moet** voltooi en ingegee word.

1. Students are allowed into the venue in the first half hour of a session, but no extra time is granted.
2. No student is allowed to leave the venue before half an hour of the examination session has elapsed.
3. Students bring bags to the venue at **own risk**, and must put them in front of the room.
4. Students may not have cell phones/electronic devices with them and/or handle them.
5. No refreshments are allowed in the examination venue.
6. Students may not leave the room for a smoke break.
7. Write on both sides of each page.
8. Write in black or blue ink only.
9. No pages may be removed from the answer scripts.
10. Students may not have unauthorized material with them during a session, e.g. notes and/or objects that contain notes.
11. No items may be borrowed during the session.
12. Students may not attempt to assist another student, or attempt to obtain assistance.
13. Students **must** hand in their answer scrips to invigilators before they leave the venue.
14. The attendance slip on the back cover that also serves as an undertaking, **must** be completed and handed in.

LEES DIE VOLGENDE INSTRUKSIES DEEGLIK

Antwoorde op vrae moet in die oopgelate ruimtes by elke vraag gegee word.

Die rugkante van bladsye kan ook gebruik word maar dan moet dit duidelik by die vraag aangedui word. Dit kan ook vir rofwerk gebruik word.

Die vraestel moet in pen voltooi word.

Die volgende tabelle is aangeheg: **(Jy mag bladsye 18 tot 23 afskeur vir gebruik. Moet dit nie inhandig saam met jou antwoordstel nie.)**

- ’n Periodieke tabel
- ’n Oplosbaarheidstabel
- ’n Tabel met geselekteerde termodinamiese waardes
- ’n Tabel met K_{sp}-waardes
- 'n Tabel met suur-basis eienskappe van soute
- ’n Tabel met ionisasiekonstantes van sommige sure en hul gekonjugeerde basisse

Sakrekenaars is toelaatbaar. Die sakrekenaarfasiliteit op selfone word nie toegelaat nie.

Avogadrogetal (N_A): 6,022 x 10^{23} mol^{-1}

Alle berekeninge moet getoon word!

READ THE FOLLOWING INSTRUCTIONS THOROUGHLY

Answers on questions must be given in the blank spaces below each question.

The back of pages can also be used, but it should then be indicated at each question. It can also be used for own scribbling.

The paper must be completed in pen.

The following tables are attached: ***(You may tear off pages 18 to 23 for use. Do not hand it in with your answer sheets.)***

- *A periodic table*
- *A solubility table*
- *A table with selected thermodynamic values*
- *A table of* K_{sp} values
- *A table with acid-base properties of salts*
- *A table with ionization constants of some acids and its conjugated basses*

Calculators are allowed. The calculator facility on mobile phones is not allowed.

Avogadro's number (N_A)*: 6,022 x* 10^{23} mol^{-1}

All calculations must be shown!

Vraag 1. / *Question 1.* **[10 PUNTE. / *10 MARKS.*]**

ATOME, IONE EN MOLEKULES. / *ATOMS, IONS AND MOLECULES.*

1.1 Skryf formule of die naam vir die volgende verbindings. / *Write the formula or the name for the following compounds.* **[3]**

Naam van verbinding. *Name of compound.*	Formule van verbinding. *Formula of compound.*
Silwer(I)oksied / *Silver(I) oxide*	**Ag_2O**
Bariumperchloraat / *Barium perchlorate*	**$Ba(ClO_4)_2$**
Kobalt(III)sianied. / Cobalt(III) cyanide	$Co(CN)_3$

1.2 Watter van die volgende atome het die grootste aantal protone? / *Which of the following atoms contains the largest number of protons?* **[1]**

a. ^{226}Ra b. ^{227}Ac c. ^{232}Th **d.** **^{231}Pa**

e. ^{222}Rn

1.3 Watter van die volgende is korrek vir 'n element met 28 protone en 31 neutrone? / *Which of the following is correct for an element with 28 protons and 31 neutrons?*

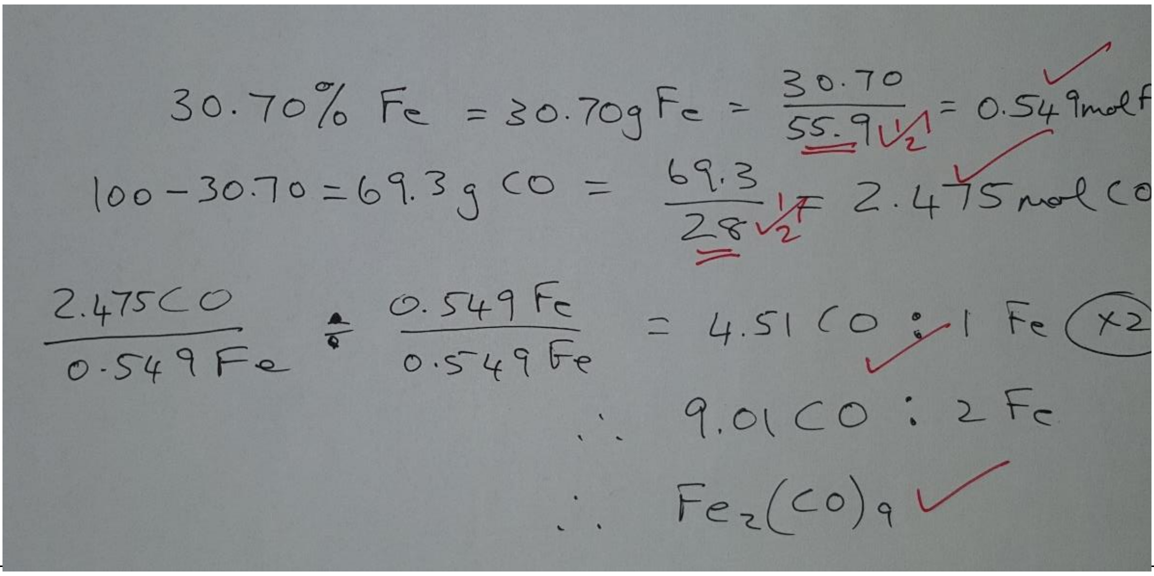
[1]

a. $^{59}_{31}Ga$ b. $^{31}_{28}Ni$ c. $^{28}_{59}Pr$ **d.** $^{59}_{28}Ni$

e. $^{31}_{3}Li$

1.4 $Fe_x(CO)_y$ bestaan uit 30,70% yster. Bereken die eenvoudigste (empiriese) formule van die verbinding.

$Fe_x(CO)_y$ consists of 30,70% iron. Calculate the simplest (empirical) formula of the compound. **[5]**



$30.70\%\ Fe = 30.70g\ Fe = \frac{30.70}{55.9}$ ✓½ $= 0.549 mol F$ ✓

$100 - 30.70 = 69.3 g\ CO = \frac{69.3}{28}$ ✓½ $= 2.475 mol\ CO$ ✓

$\frac{2.475 CO}{0.549 Fe} \div \frac{0.549 Fe}{0.549 Fe} = 4.51\ CO : 1\ Fe$ ✓ (×2

$\therefore\ 9.01\ CO : 2\ Fe$

$\therefore\ Fe_2(CO)_9$ ✓

Vraag 2. / *Question 2.* **[12 PUNTE. / *12 MARKS.*]**

CHEMIESE REAKSIES. / *CHEMICAL REACTIONS.*

2.1 Voltooi en benoem die chemiese reaksietipes van die volgende reaksies in waterige oplossings:
Complete and name the chemical reaction types of the following reactions in aqueous solution:

[6]

2.1.1 $Hg_2(NO_3)_2(aq) + CuSO_4(aq) \rightarrow Hg_2SO_4(s) + Cu(NO_3)_2(aq)$ ☑☑ precipitation

2.1.2 $Ca(OH)_2(aq) + 2HCl(aq) \rightarrow CaCl_2(aq) + 2H_2O(l)$ ☑☑ acid-base

2.1.3 $2Al(s) + 6HCl(aq) \rightarrow 2AlCl_3(aq) + 3H_2(g)$ ☑☑ redox – displacement

2.2 Balanseer die volgende oksidasie-reduksie reaksie wat plaasvind in basiese oplossing deur van die half-reaksie metode gebruik te maak. / *Balance the following oxidation-reduction reaction which occur in basic solution using the half-reaction method.* **[6]**

$$\mathbf{Al(s) + MnO_4^-(aq) \rightarrow MnO_2(s) + Al(OH)_4^-(aq)}$$

Oxidation numbers: Al = 0 Mn = +7 Mn = +4 Al = +3 ☑☑

O½: $Al + 4OH^- \rightarrow Al(OH)_4^- + 3é$ ☑

R½: $\underline{MnO_4^- + 2H_2O + 3é \rightarrow MnO_2 + 4OH^-}$ ☑

$Al(s) + MnO_4^-(aq) + 2H_2O(l) \leftrightarrows Al(OH)_4^-(aq) + MnO_2(s)$ ☑☑

Vraag 3. / *Question 3.* **[10 PUNTE. / *10 MARKS.*]**

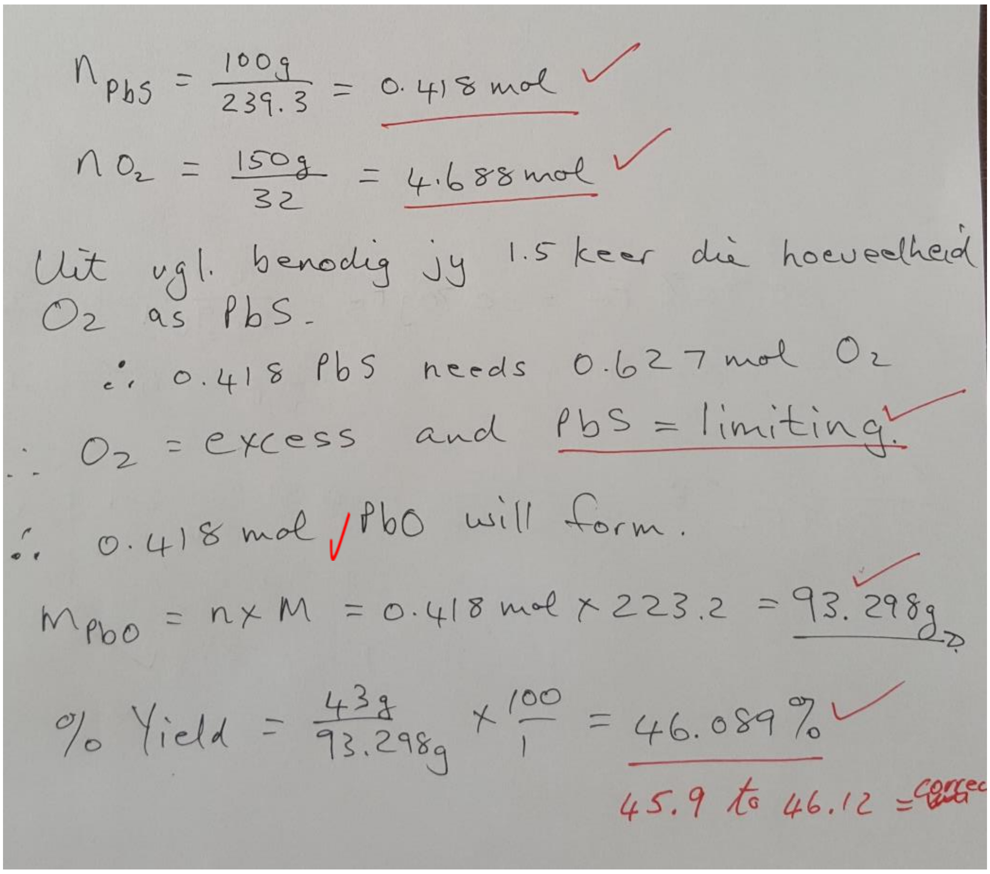
STOIGIOMETRIE. / *STOICHIOMETRY.*

3.1 Gegee die volgende vergelyking: / *Given the following equation*:

$$2PbS(s) + 3O_2(g) \rightarrow 2PbO(s) + 2SO_2(g)$$

Indien 100 g PbS(s) reageer met 150 g O_2(g) en slegs 43 g PbO(s) word gevorm, wat is die persentasie opbrengs van die reaksie? / *If 100 g PbS(s) react with 150 g O_2(g) and only 43 g PbO(s) is formed, what is the percentage yield of the reaction?* **[6]**

(**Gegee: / *Given***: M_{PbS} = 239.3 g.mol^{-1}; M_{O2} = 32 g.mol^{-1}; M_{PbO} = 223.2 g.mol^{-1}).



$n_{PbS} = \frac{100g}{239.3} = \underline{0.418 \text{ mol}}$ ✓

$n_{O_2} = \frac{150g}{32} = \underline{4.688 \text{ mol}}$ ✓

Uit vgl. benodig jy 1.5 keer die hoeveelheid O_2 as PbS.

∴ 0.418 PbS needs 0.627 mol O_2

∴ O_2 = excess and $\underline{PbS = \text{limiting}}$ ✓

∴ 0.418 mol ✓ PbO will form.

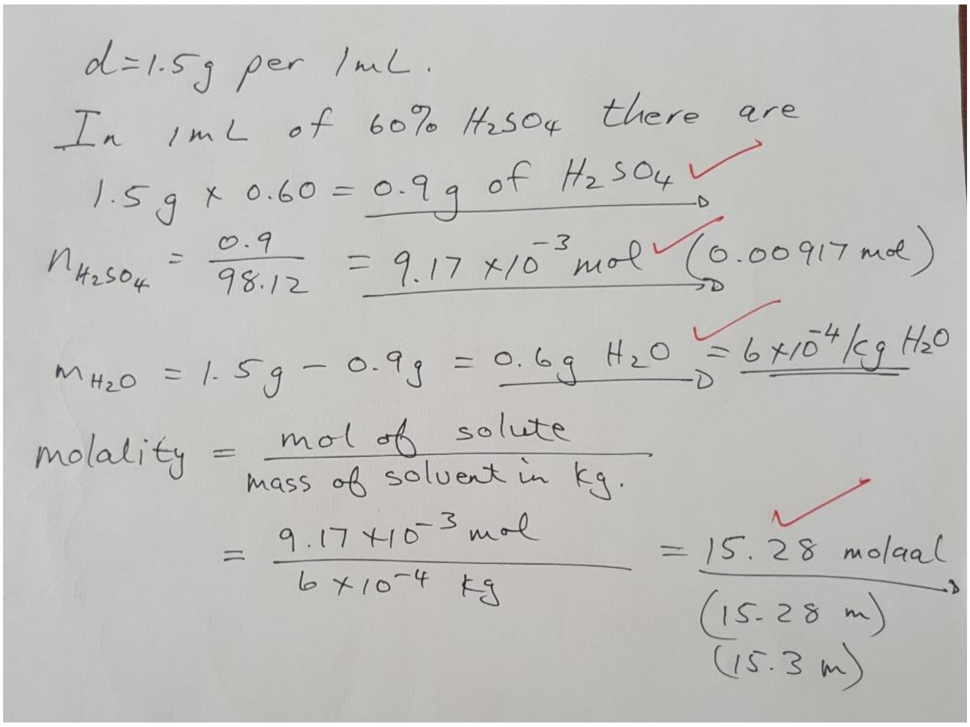
$m_{PbO} = n \times M = 0.418 \text{ mol} \times 223.2 = \underline{93.298g}$ ✓

$\% \text{ Yield} = \frac{43g}{93.298g} \times \frac{100}{1} = \underline{46.089\%}$ ✓

45.9 to 46.12 = Correc

3.2 Gekonsentreerde swaelsuur (98.12 g.mol^{-1}) het 'n digtheid van 1.5 g/cm^3 en is 60 % H_2SO_4 per massa. Die res is water. Bereken die molaliteit van die suur. / *Concentrated sulphuric acid (98.12 g.mol^{-1}) has a density of 1.5 g/cm^3 and is 60 % H_2SO_4 per mass. The rest is water. Calculate the molality of the acid.*

[4]



d = 1.5g per 1mL.

In 1mL of 60% H_2SO_4 there are

$1.5g \times 0.60 = \underline{0.9g \text{ of } H_2SO_4}$ ✓

$n_{H_2SO_4} = \frac{0.9}{98.12} = \underline{9.17 \times 10^{-3} \text{ mol}}$ ✓ (0.00917 mol)

$m_{H_2O} = 1.5g - 0.9g = \underline{0.6g \; H_2O}$ ✓ $= \underline{6 \times 10^{-4} \text{ kg } H_2O}$

$\text{molality} = \frac{\text{mol of solute}}{\text{mass of solvent in kg.}}$

$= \frac{9.17 \times 10^{-3} \text{ mol}}{6 \times 10^{-4} \text{ kg}} = \underline{15.28 \text{ molaal}}$ ✓

(15.28 m)

(15.3 m)

Vraag 4. / *Question 4.* **[10 PUNTE. / *10 MARKS.*]**

ENERGIEOORDRAG (TERMODINAMIKA). / *ENERGY TRANSFER (THERMODINAMICS).*

4.1 Gegewe die volgende data: / *Given the following data:* **[4]**

(i)	$Ca(s) + 2C(grafite) \rightarrow CaC_2(s)$	$\Delta H = -62.8$ kJ
(ii)	$Ca(s) + ½O_2(g) \rightarrow CaO(s)$	$\Delta H = -635.5$ kJ
(iii)	$CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(aq)$	$\Delta H = -653.1$ kJ
(iv)	$C_2H_2(g) + 5/2O_2(g) \rightarrow 2CO_2(g) + H_2O(l)$	$\Delta H = -1300.0$ kJ
(v)	$C(grafite) + O_2(g) \rightarrow CO_2(g)$	$\Delta H = -393.5$ kJ

Bereken ΔH vir die volgende reaksie, deur van Hess se wet en manipulasie van die gegewe reaksies gebruik te maak. / Calculate ΔH for the following reaction by using Hess's law and manipulating the given reactions:

$CaC_2(s) + H_2O(l) \rightarrow Ca(OH)_2(aq) + C_2H_2(g)$ **ΔH = ?**

(i)	Reverse $CaC_2(s) \rightarrow Ca(s) + 2C(grafite)$	$\Delta H = +62.8$ kJ	☑
(ii)	$Ca(s) + ½O_2(g) \rightarrow CaO(s)$	$\Delta H = -635.5$ kJ	
(iii)	$CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(aq)$	$\Delta H = -653.1$ kJ	
(iv)	Reverse $2CO_2(g) + H_2O(l) \rightarrow C_2H_2(g) + 5/2O_2(g)$	$\Delta H = +1300.0$ kJ	☑
(v)	(x2) $2C(grafite) + 2O_2(g) \rightarrow 2CO_2(g)$	$\underline{\Delta H = 2(-393.5 \text{ kJ})}$	☑
		$\Delta H = -712.8$ kJ	☑

4.2 Definieer die term spesifieke hittekapasiteit. / *Define the term specific heat capacity.* **[2]**

Energy transfer as heat that is required to raise the temperature of 1 gram of a substance by one kelvin.

✓✓

4.3 'n Stukkie chroom (15.5 g) word verhit tot 100.0 °C (373.15 K) en dan in 55.5 g water by 16.5 °C (289.65 K) laat val. Die finale temperatuur van die metaal en water is 18.9 °C. Bereken die spesifieke hittekapasiteit van chroom. (Aanvaar dat geen energie verlore gegaan het na die houer of die omringende lug nie). Die spesifieke hittekapasiteit van water is 4.184 J/g.K). / *A 15.5 g piece of chromium is heated to 100.0 °C (373.15 K) and is then dropped into 55.5 g of water at 16.5 °C (289.65 K). The final temp. of the metal and water is 18.9 °C. Calculate the specific heat capacity of chromium. (Assume no energy is lost to the container or to the surrounding air). The specific heat capacity of water is 4.184 J/g.K).* **[4]**

Because of conservation of energy, ✓

$q_{(Cr)} = -q_{(H2O)}$ (energy out of Cr = energy into H_2O)

or $q_{(Cr)} + q_{(H2O)} = 0$

$q_{(Cr)}$ = (15.5 g)(C_p)(18.9 ˚C – 100.0 ˚C)

$q_{(Cr)}$ = –1257.05 X C_p ✓

$q_{(H2O)}$ = (55.5 g)($\underline{\text{4.184 J/K•g}}$)(18.9 ˚C – 16.5 ˚C)

$q_{(H2O)}$ = 557.3088 J ✓

$q_{(Cr)} + q_{(H2O)}$ = – 1257.05 C_p + 557.309 = 0 → $\underline{C_p \text{ = 0.443 J/g•K}}$ ✓

Laat vir 'n klein speling toe op die antwoord, a.g.v. verskillende maniere van afronding.

Vraag 5. / *Question 5.* **[20 PUNTE. / *20 MARKS.*]**

CHEMIESE EWEWIG. / *CHEMICAL EQUILIBRIUM.*

5.1 K_c vir die ontbinding van ammoniumwaterstofsulfied is 1.8 x 10^{-4} by 25^0C. / *K_c for the decomposition of ammonium hydrogen sulfide is 1.8 x 10^{-4} at 25^0C.*

$$NH_4HS(s) \leftrightarrows NH_3(g) + H_2S(g)$$

5.1.1 Bereken die ewewigskonsentrasies van beide produkte wanneer die suiwer sout ontbind in 'n fles. / *Calculate the equilibrium concentrations of both products when the pure salt decomposes in a flask.* **[2]**

K = [NH_3] [H_2S] = 1.8 x 10^{-4} = x^2 ☑

X = square root 1.8 x 10^{-4} = 0.0134 mol/L = [NH_3] = [H_2S] ☑

5.1.2 Indien NH_4HS in 'n fles geplaas word wat alreeds 0.020 mol/L NH_3 bevat en die sisteem dan toegelaat word om ewewig te bereik, bereken dan die ewewigskonsentrasies van NH_3 en H_2S.

If NH_4HS is placed in a flask already containing 0.020 mol/L of NH_3 and then the system is allowed to come to equilibrium, calculate the equilibrium concentrations of NH_3 and H_2S? **[4]**

K = [NH_3] [H_2S] = 1.8 x 10^{-4} = (0.020 + x) x = (0.02)x ☑

X = (1,8 x 10^{-4}) / 0.020 = 0.009 ☑

[NH_3] = 0.020 + 0.009 = 0.029 mol/L ☑ with quadratic eq = 0.027 mol/L

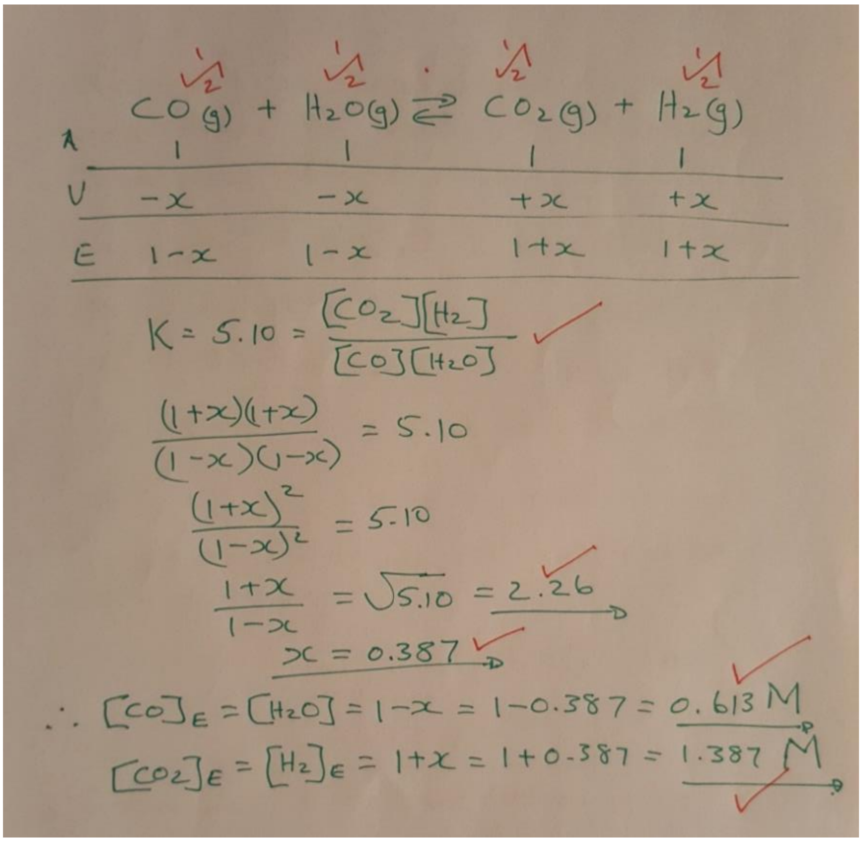
[H_2S] = 0.009 mol/L ☑ with quadratic eq = 0.0067 mol/L

X = (-b ± (b^2 – 4ac)^{½}) / 2a with equation x^2 + 0.02 x – 0.00018 = 0

$X = (-0.02 \pm (0.02^2 - 4(-0.00018))^{½}) / 2 = (-0.02 \pm (0.0004 + 0.00072)^{½}) / 2 = (-0.02 + 0.0335)/2 = 0.0135/2$

$X = 0.0067$ mol/L

5.2 Koolstofmonoksied reageer met stoom om koolstofdioksied en waterstofgas te produseer. By 700 K is die ewewigskonstante gelyk aan 5.10. Bereken die ewewigskonsentrasies van al die spesies indien met 1.00 mol.L^{-1} van elk begin is. / *Carbon monoxide reacts with steam to yield carbon dioxide and hydrogen gas. At 700 K the equilibrium constant is equal to 5.10. Calculate the equilibrium concentrations of all the species if the reaction was started with 1.00 mol.L^{-1} of each.* **[7]**



$\overset{✓½}{CO(g)} + \overset{✓½}{H_2O(g)} \rightleftarrows \overset{✓½}{CO_2(g)} + \overset{✓½}{H_2(g)}$

A	1	1	1	1
V	$-x$	$-x$	$+x$	$+x$
E	$1-x$	$1-x$	$1+x$	$1+x$

$K = 5.10 = \frac{[CO_2][H_2]}{[CO][H_2O]}$ ✓

$\frac{(1+x)(1+x)}{(1-x)(1-x)} = 5.10$

$\frac{(1+x)^2}{(1-x)^2} = 5.10$

$\frac{1+x}{1-x} = \sqrt{5.10} = 2.26$ ✓

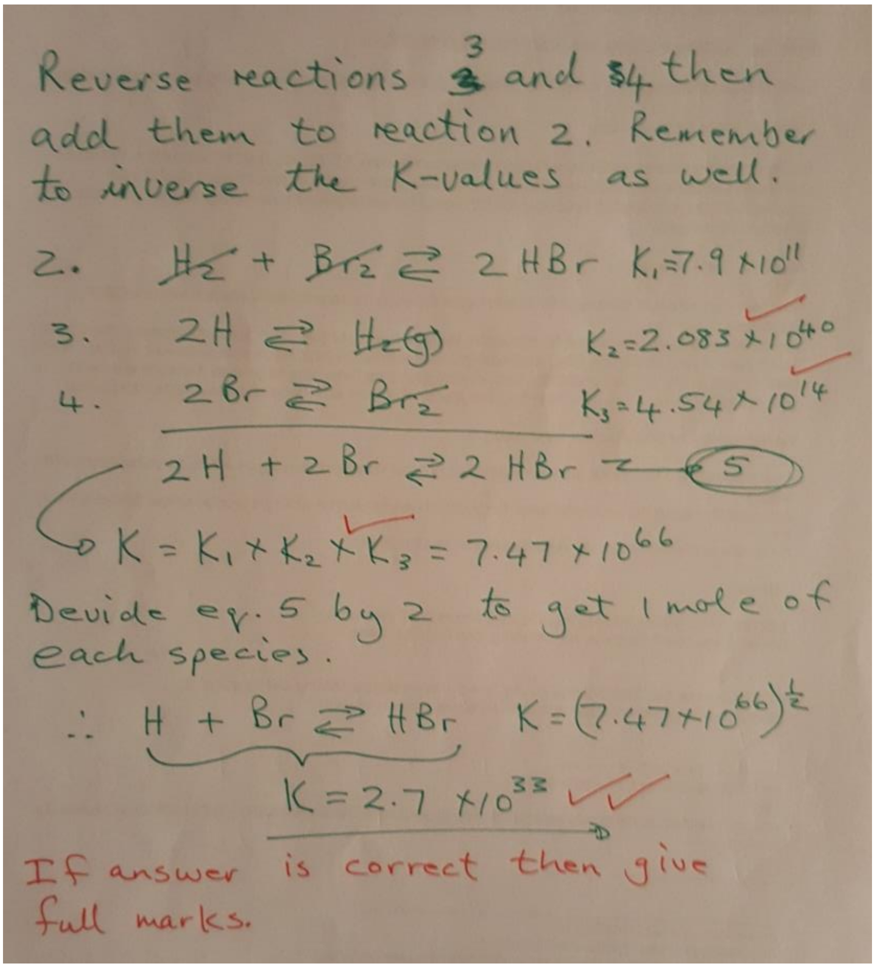
$x = 0.387$ ✓

$\therefore [CO]_E = [H_2O] = 1-x = 1-0.387 = 0.613\ M$ ✓

$[CO_2]_E = [H_2]_E = 1+x = 1+0.387 = 1.387\ M$ ✓

5.3 Bepaal die ewewigskonstante K vir die vorming van HBr volgens die reaksie hieronder genommer 1 deur gebruik te maak van die ewewigskonstantes van die reaksies genommer 2 tot 4. / *Determine the equilibrium constant K for the formation of HBr according to the reaction numbered 1 below by using the equilibrium constants of the reactions numbered 2 to 4.* **[5]**

1.	$H(g) + Br(g) \rightleftharpoons HBr(g)$	K = ?
2.	$H_2(g) + Br_2(g) \rightleftharpoons 2HBr(g)$	$K_1 = 7.9 \times 10^{11}$
3.	$H_2(g) \rightleftharpoons 2H(g)$	$K_2 = 4.8 \times 10^{-41}$
4.	$Br_2(g) \rightleftharpoons 2Br(g)$	$K_3 = 2.2 \times 10^{-15}$



Reverse reactions $\overset{3}{\cancel{3}}$ and ~~3~~4 then add them to reaction 2. Remember to inverse the K-values as well.

$$2.\quad \cancel{H_2} + \cancel{Br_2} \rightleftarrows 2HBr \quad K_1 = 7.9 \times 10^{11}$$

$$3.\quad 2H \rightleftarrows \cancel{H_2(g)} \quad K_2 = 2.083 \times 10^{40} ✓$$

$$4.\quad 2Br \rightleftarrows \cancel{Br_2} \quad K_3 = 4.54 \times 10^{14} ✓$$

$$2H + 2Br \rightleftarrows 2HBr \leftarrow \boxed{5}$$

$$K = K_1 \times K_2 \times K_3 = 7.47 \times 10^{66} ✓$$

Devide eq. 5 by 2 to get 1 mole of each species.

$$\therefore \underbrace{H + Br \rightleftarrows HBr}_{K = 2.7 \times 10^{33}} \quad K = (7.47 \times 10^{66})^{\frac{1}{2}}$$

$$K = 2.7 \times 10^{33} ✓✓$$

If answer is correct then give full marks.

5.4 Sal jy (op grond van jou antwoord in vraag 5.3) sê dat reaksie nommer 1 'n hoë produk opbrengs sal hê? Omkring JA of NEE en gee 'n rede vir jou antwoord. / *Will you (on the basis of your answer in question 5.3) say that reaction number 1 will have a high product yield? Circle YES or NO and give a reason for your answer.* **[2]**

JA (*YES*). ✓ NEE (*NO*)

Rede: K > 1 ✓

Vraag 6. / *Question 6.* [20 PUNTE. / *20 MARKS.*]

SURE EN BASISSE. / *ACIDS AND BASES.*

6.1 Bereken die massa KOH wat nodig is om 'n 800.0 mL oplossing met 'n pH = 11.56 voor te berei.

Calculate the mass of KOH necessary to prepare 800.0 mL of a solution that has a pH = 11.56.

[4]

pOH = 14 – pH = 14 – 11.56 = 2.44 ☑

$[OH^-] = 10^{-pOH} = 10^{-2.44}$ = 0.00363 mol/L ☑

Strong base [KOH] = $[OH^-]$ = 0.00363 mol/L

1000 mL equal 0.00363 mol

800 mL equal (0.00363 x 800)/1000 = 0.00290 mol ☑

Mass = nM = 0.00290 x (39.1 + 16 + 1.01 = 56.11) = 0.163 gram ☑

6.2 Sitroensuur ($H_3C_6H_5O_7$) is 'n triprotiese suur met 'n $K_{a1} = 8.4 \times 10^{-4}$; $K_{a2} = 1.8 \times 10^{-5}$ en $K_{a3} = 4.0 \times 10^{-6}$. Bereken die pH van 'n 0.15 M sitroensuuroplossing. / *Citric acid ($H_3C_6H_5O_7$) is a tri-protic acid with $K_{a1} = 8.4 \times 10^{-4}$; $K_{a2} = 1.8 \times 10^{-5}$ and $K_{a3} = 4.0 \times 10^{-6}$. Calculate the pH of 0.15 M citric acid solution.*

[5]

$H_3C_6H_5O_7 + H_2O \leftrightarrows H_2C_6H_5O_7^- + H_3O^+$ ☑

$K_{a1} = x^2 / 0.15 = 8.4 \times 10^{-4}$ {ignore x in (0.15 – x) because $0.15 / 8.4 \times 10^{-4}$ = 178.57 > 100}

$X^2 = 0.150 \times 8.4 \times 10^{-4} = 0.000126$ ☑

X = 0.01122 ☑

pH = -log $[H^=]$ = -log (0.01122) = 1.949 ☑

The pH is determined ONLY by the first K_a ☑

Indien 'n student nie aangedui het dat die pH deur slegs die 1ste Ka-waarde bepaal word nie, maar die pH wel reg bereken het kan die student nog steeds volpunte kry.

6.3 In 'n waterige oplossing wat 10^{-8} M soutsuur (HCL) en 10^{-8} M asynsuur (CH_3COOH) bevat sal die H^+-ione hoofsaaklik verskaf word deur .... / *In an aqueous solution containing 10^{-8} M (hydrochloric acid) HCl and 10^{-8} M acetic acid (CH_3COOH) the H^+ ions will mostly be supplied by ....* **[1]**

A) die sterk suur. / *the strong acid.* ✓

B) die swak suur. / *the weak acid.*

C) beide die sterk en die swak sure. / *both the strong and the weak acids.*

D) water. / *water.*

6.4 Die sianiedioon, CN^-, ontvang ‘n proton vanaf water om HCN te vorm. Is CN^- ‘n Brønsted-Lowry suur of basis of is dit amfiproties? / *The cyanide ion, CN^-, accepts a proton from water to vorm HCN. Is CN^- a Brønsted-Lowry acid or base or is it amphiprotic?* **[1]**

Base ✓

6.5 Bereken die pKa waarde van die gekonjugeerde suur van ammoniak. / *Calculate the pK_a value for the conjugate acid of ammonia?* **[2]**

The conjugate acid of ammonia is NH_4^+

K_a for NH_4^+ = 5.6×10^{-10}

$pK_a = -\log(5.6 \times 10^{-10}) = \underline{9.25}$ ✓ ✓

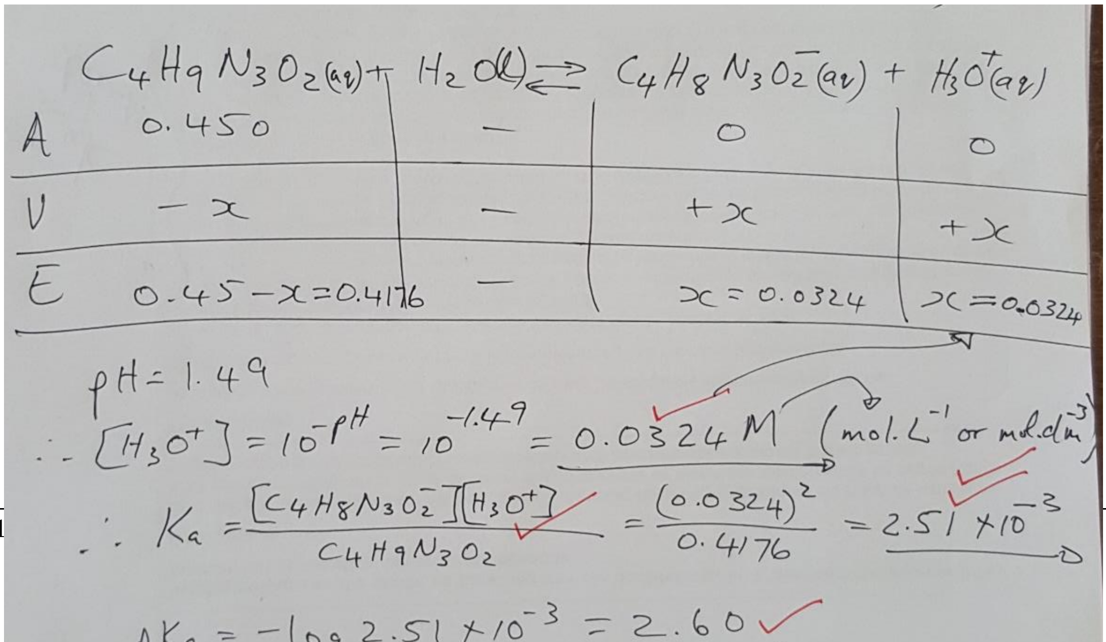
6.6 Watter een van die volgende sure het ‘n pKa waarde van 4.20? / *Which one of the following acids has a pK_a value of 4.20?* **[2]**

a) $C_6H_5CO_2H$ **b) CH_3CO_2H** ✓✓ c) HCO_2H d) HF

K_a from $pK_a = 10^{-pKa}$

$10^{-4.20} = 6.3 \times 10^{-5}$ Ka for $C_6H_5CO_2H = 6.3 \times 10^{-5}$

6.7 ‘n 0.450 M waterige oplossing van kreatien, ($C_4H_9N_3O_2$), het ‘n pH van 1.49. Bereken die waarde van die ewewigskonstante van kreatien sowel as die pK_a waarde. / *A 0.450 M aqueous solution of creatine, ($C_4H_9N_3O_2$), has a pH of 1.49. Calculate the value of the equilibrium constant for creatine as well as the pK_a value.* **[5]**



$$C_4H_9N_3O_2(aq) + H_2O(l) \rightleftharpoons C_4H_8N_3O_2^-(aq) + H_3O^+(aq)$$

A	0.450	—	0	0
V	$-x$	—	$+x$	$+x$
E	$0.45-x=0.4176$	—	$x=0.0324$	$x=0.0324$

pH = 1.49

$\therefore [H_3O^+] = 10^{-pH} = 10^{-1.49} = \underline{0.0324\ M}$ ✓ ($mol.L^{-1}$ or $mol.dm^{-3}$)

$\therefore K_a = \dfrac{[C_4H_8N_3O_2^-][H_3O^+]}{C_4H_9N_3O_2}$ ✓ $= \dfrac{(0.0324)^2}{0.4176} = \underline{2.51 \times 10^{-3}}$ ✓✓

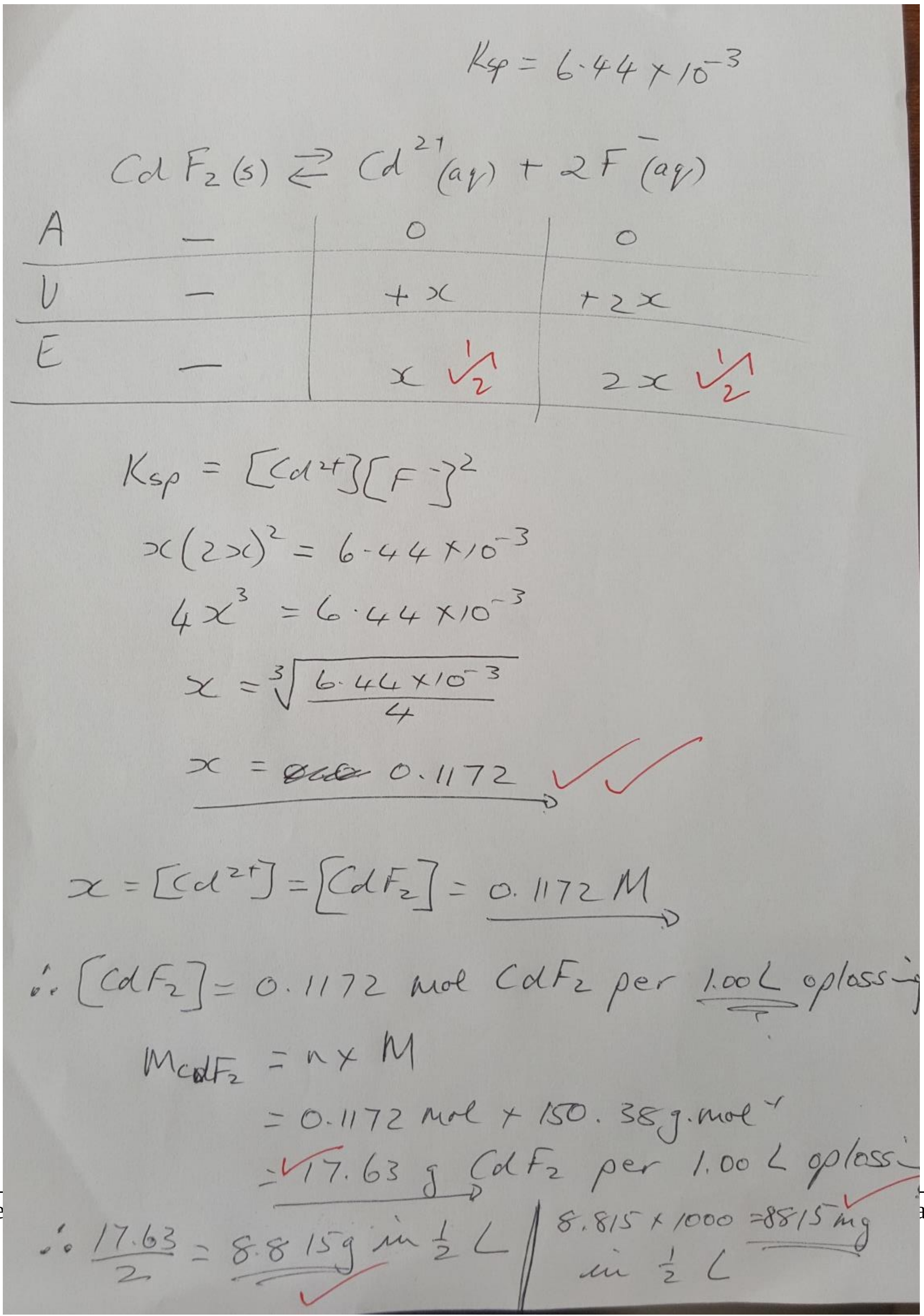
$pK_a = -\log 2.51 \times 10^{-3} = 2.60$ ✓

Vraag 7. / *Question 7.* **[20 PUNTE. / *20 MARKS.*]**

ANDER ASPEKTE VAN WATERIGE EWEWIGTE. / *OTHER ASPECTS OF AQUEOUS EQUILIBRIA.*

7.1 Die oplosbaarheidsproduk-konstante van kadmiumfluoried is 6.44 x 10^{-3} by 25^0C. Bereken die hoeveelheid (in gram en in milligram) CdF_2 wat sal oplos in 'n half liter water by 25^0C. / The solubility product constant of cadmium fluoride is 6.44 x 10^{-3} at 25^0C. Calculate the amount (in gram and in milligram) of CdF_2 that will dissolve in half a litre of water at 25^0C. **[6]**

(**Gegee: / *Given:*** M_{H2O} = 18.02 g.mol^{-1} en/*and* M_{CdF2} = 150.38 g.mol^{-1})



$K_{sp} = 6.44 \times 10^{-3}$

$$CdF_2(s) \rightleftarrows Cd^{2+}(aq) + 2F^-(aq)$$

A	—	0	0
V	—	$+x$	$+2x$
E	—	x ✓$\frac{1}{2}$	$2x$ ✓$\frac{1}{2}$

$K_{sp} = [Cd^{2+}][F^-]^2$

$x(2x)^2 = 6.44 \times 10^{-3}$

$4x^3 = 6.44 \times 10^{-3}$

$x = \sqrt[3]{\frac{6.44 \times 10^{-3}}{4}}$

$x =$ ~~[illegible]~~ 0.1172 ✓✓

$x = [Cd^{2+}] = [CdF_2] = 0.1172\ M$

$\therefore [CdF_2] = 0.1172$ mol CdF_2 per 1.00 L oploss

$M_{CdF_2} = n \times M$

$= 0.1172 \text{ mol} \times 150.38 \text{ g.mol}^{-1}$

$=$ ✓ 17.63 g CdF_2 per 1.00 L oploss

$\therefore \frac{17.63}{2} = 8.815$ g in $\frac{1}{2}$ L ✓ | 8.815 × 1000 = 8815 mg ✓ in $\frac{1}{2}$ L

7.2 Definieer 'n bufferoplossing. Van wat word 'n bufferoplossing berei? Beskryf hoe buffers bygevoegde H^+- en OH^--ione absorbeer sodat 'n baie klein pH verandering plaasvind. 'n Sekere buffer is berei deur $NaHCO_3$ en $NaCO_3$ in water op te los. Skryf reaksievergelykings neer wat wys hoe die buffer bygevoegde H^+- en OH^--ione sal neutraliseer.

Define a buffer solution. What makes up a buffered solution? Explain how buffers absorb added H^+ or OH^- with little pH change. A certain buffer is made by dissolving $NaHCO_3$ and Na_2CO_3 in come water. Write equations to show how this buffer neutralizes added H^+ and OH^-. **[6]**

A buffer solution is a solution that resists a change in its pH when H^+ or OH^- are added. ☑

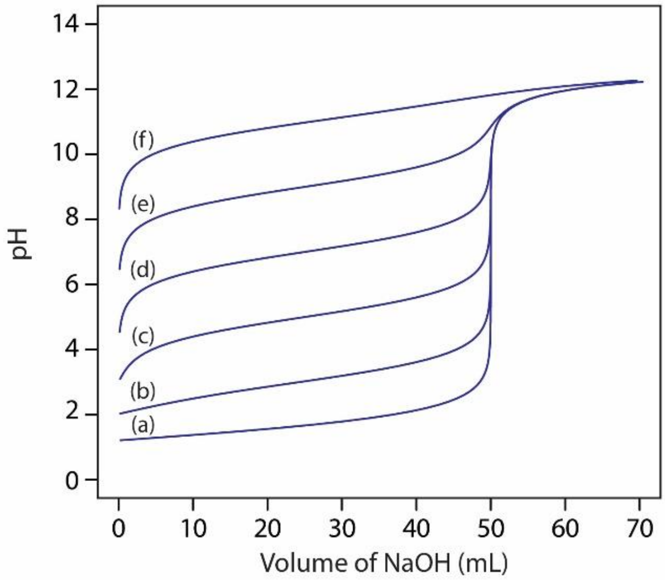
Any solution that contains a weak acid and its conjugate base OR a weak base and its conjugate acid, is classified as a buffer. ☑

The pH of the buffer depends on the [base] / [acid] ratio. **When H^+** is added to the buffer, the weak base component of the buffer reacts with the H^+ and forms the acid component of the buffer. Even though the concentrations of the acid and the base components of the buffer change some, the ratio of [base] / [acid] does not change that much. **When OH^-** is added to the buffer, the weak acid component of the buffer reacts with the OH^- and forms the base component of the buffer. Again, the ratio of [base] / [acid] does not change a lot, so that the pH does not change much. ☑☑

Buffer HCO_3^- and CO_3^{2-}

H^+ $+ CO_3^{2-} \leftrightarrows HCO_3^-$ ☑ OR **OH^-** $+ HCO_3^- \leftrightarrows H_2O + CO_3^{2-}$ ☑

7.3 Die volgende grafiek wys die pH kurwes vir titrasies van verskeie sure met 0.10 M NaOH (al die sure was 50.0 mL monsters met konsentrasies van 0.10 M). / *The following plot shows the pH curves for the titrations of various acids with 0.10 M NaOH (all the acids were 50,0 mL samples of 0.10 M concentration).*



7.3.1 Watter pH kurwe stem ooreen met die swakste suur? Gee 'n rede vir jou antwoord. / *Which pH curve corresponds to the weakest acid? Give a reason for your answer.* **[2]**

(f) is the curve of the weakest acid. ☑ The acid is in the flask and NaOH is added from the burette. The acid is so weak that after the first drops of base is added the pH immediately change from acidic to basic at pH = 9 before 5 mL of base is added. ☑

7.3.2 Watter pH kurwe stem ooreen met die sterkste suur? Gee 'n rede vir jou antwoord. / *Which pH curve corresponds to the strongest acid? Give a reason for your answer.* **[2]**

(a) is the strongest acid. ☑ The pH of the acid stays almost constant at pH = 1.3 until 20 mL base is added. Only when 50 mL base is added does the pH change dramatically. ☑

7.3.3 Watter punt op die pH kurwe sal jy bestudeer om te sien of die suur 'n sterk suur of 'n swak suur is? / *Which point on the pH curve would you examine to see if the acid is a strong acid or a weak acid?* **[2]**

The best point to look at to differentiate a strong acid from a weak acid (if initial concentrations are similar and the base is NaOH) is the equivalence point pH. If the pH = 7 the acid is strong, if the pH is greater than 7, the acid is weak. ☑☑ (The shape of the curve at the beginning and the end of the plot can also be used.)

7.3.4 Watter pH kurwe stem ooreen met 'n suur met 'n $K_a = 1 \times 10^{-6}$? Gee 'n rede vir jou antwoord. Which pH curve corresponds to an acid with $K_a = 1 \times 10^{-6}$? Give a reason for your answer. **[2]**

(d). ☑ $pK_a = - \log K_a = -\log 1 \times 10^{-6} = 6$.

At the halfway point to the equivalence point in the titration pH = pK_a. Therefore curve (d) is the nearest to pH 6 at the halfway point. ☑

JY MAG VANAF BLADSY 18 TOT DIE LAASTE BLADSY AFSKEUR VIR GEBRUIK. MOET DIT NIE SAAM MET JOU VRAESTEL INHANDIG NIE. JY KAN DIT WEGGOOI NA AFLOOP VAN DIE VRAESTEL. / ***YOU MAY TEAR OFF PAGE 18 TO THE LAST PAGE TO USE. DO NOT HAND THEM IN WITH YOUR PAPER. YOU MAY THROUGH THEM AWAY AFTER COMPLETING THE PAPER.***

PERIODIC TABLE OF THE ELEMENTS
PERIODIEKE INDELING VAN DIE ELEMENTE

13	atomic number / atoomgetal
Al	symbol / simbool
27,0	atomic mass / atoommassa

IA (1)	IIA (2)	IIIB (3)		IVB (4)	VB (5)	VIB (6)	VIIB (7)	VIII (8)	(9)	(10)	IB (11)	IIB (12)	IIIA (13)	IVA (14)	VA (15)	VIA (16)	VIIA (17)	0 (18)
1 **H** 1,01																		2 **He** 4,00
3 **Li** 6,94	4 **Be** 9,01												5 **B** 10,8	6 **C** 12,0	7 **N** 14,0	8 **O** 16,0	9 **F** 19,0	10 **Ne** 20,2
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** 35,45	18 **Ar** 39,9
19 **K** 39,1	20 **Ca** 40,1	21 **Sc** 45,0		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** 63,4	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)	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** 121,6	52 **Te** 127,6	53 **I** 127,9	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** 183,9	75 **Re** 186,2	76 **Os** 190,2	77 **Ir** 192,2	78 **Pt** 195,1	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** 226,0	89 **Ac** 227,0	#	104 **Rf** (261)	105 **Db** (262)	106 **Sg** (263)	107 **Bh** (262)	108 **Hs** (265)	109 **Mt** (266)									

* lanthanides / lantaniede	58 **Ce** 140,1	59 **Pr** 140,9	60 **Nd** 144,2	61 **Pm** (145)	62 **Sm** 150,4	63 **Eu** 152,0	64 **Gd** 157,3	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 / aktiniede	90 **Th** 232,0	91 **Pa** 231,0	92 **U** 238,0	93 **Np** 237,0	94 **Pu** (244)	95 **Am** (234)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (258)	103 **Lr** (260)

TABEL 1: Oplosbaarheidstabel.

TABLE 1: Solubility Table.

Soluble compounds		**Exceptions**
Almost all salts of Na^+, K^+ and NH_4^+		
All salts of Cl^-, Br^- and I^-	⇔	Halides of Ag^+, Hg_2^{2+} and Pb^{2+}
Compounds containing F^-	⇔	Fluorides of Mg^{2+}, Ca^{2+}, Sr^{2+}, Ba^{2+} and Pb^{2+}
Salts of nitrate, NO_3^-; chlorate, ClO_3^-; perchlorate, ClO_4^-; acetate, CH_3COO^-		$KClO_4$
Salts of sulfate, SO_4^{2-}	⇔	Sulfates of Sr^{2+}, Ba^{2+} and Pb^{2+}

Insoluble compounds		**Exceptions**
All salts of carbonate, CO_3^{2-}; phosphate, PO_4^{3-} oxalate, $C_2O_4^{2-}$; chromate, CrO_4^{2-}; sulfide, S^{2-} Most metal hydroxides OH^- and oxides, O^{2-}	⇔	Salts of NH_4^+ and alkali metal cations

TABEL 2: Geselekteerde Termodinamiese Waardes.

TABLE 2: Selected Thermodynamic Values.

Species	**$\Delta_f H^o$ (298.15 K) (kJ/mol)**	**S^o (298.15 K) ($J/K.mol^{-1}$)**	**$\Delta_f G^o$ (298.15 K) (kJ/mol)**
CCl_4 (ℓ)	-128.4	214.39	- 57.63
CCl_4 (g)	-95.98	309.65	- 53.61
CH_4 (g)	-74.87	186.26	- 50.8
H_2 (g)	0	130.7	0
Al (s)	0	28.3	0
Al_2O_3 (s)	-1675.7	50.92	- 1582.3
N_2 (g)	0	191.56	0
I_2 (s)	0	116.135	0
Fe (s)	0	27.78	0
Fe_2O_3 (s)	- 825.5	87.40	- 742.2
CH_3OH (ℓ)	-238.4	127.19	- 166.14
CH_3OH (g)	-201.0	239.7	- 162.5
CO (g)	-110.525	197.674	- 137.168
CO_2 (g)	-393.509	213.74	- 394.359
O_2 (g)	0	205.07	0
H_2O (ℓ)	-285.83	69.95	- 237.15
H_2O (g)	-241.83	188.84	- 228.59

TABEL 3: Oplosbaarheidsproduk Konstantes.

TABLE 3: Solubility Produce Constants.

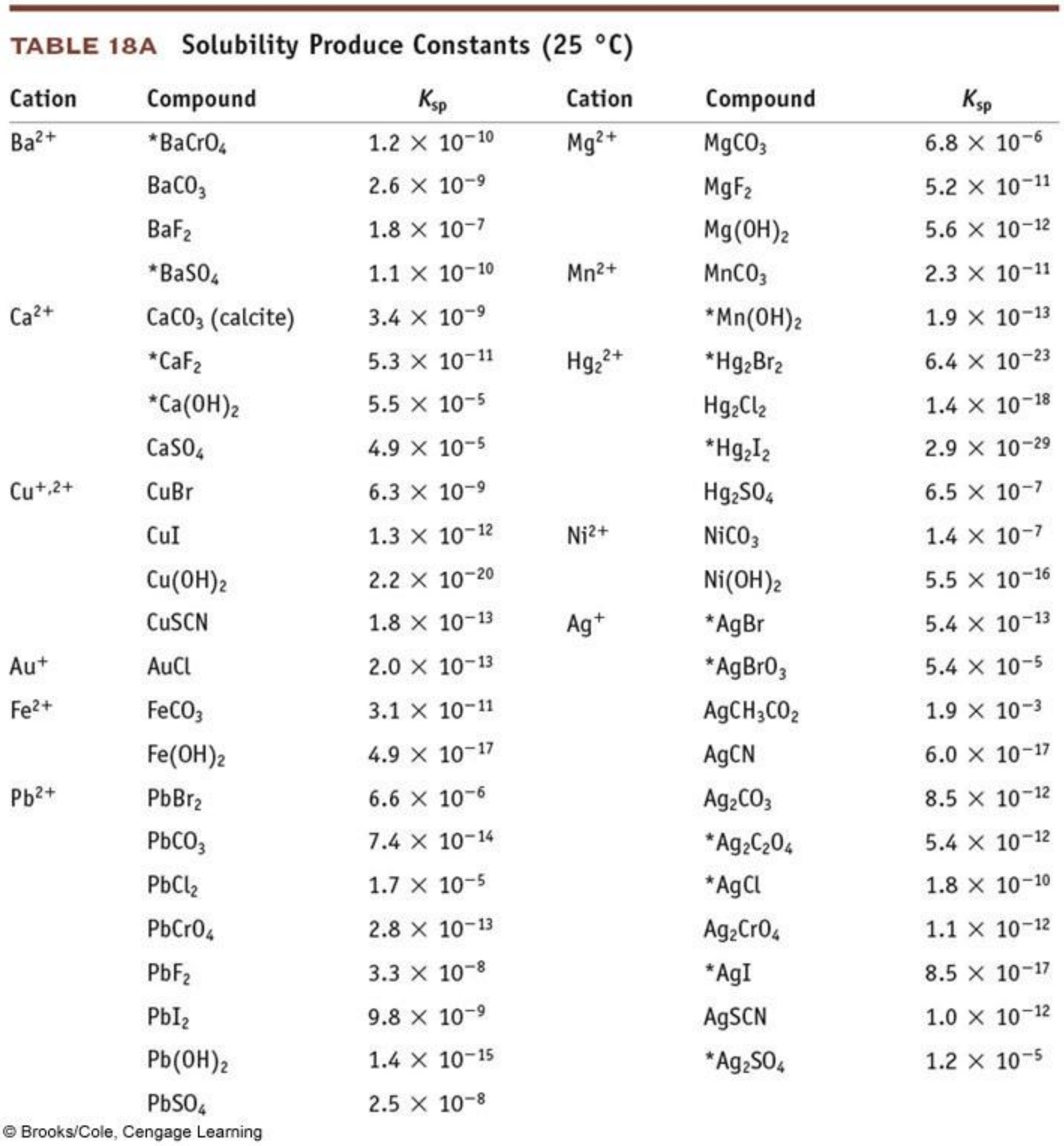


TABLE 18A Solubility Produce Constants (25 °C)

Cation	Compound	K_{sp}	Cation	Compound	K_{sp}
Ba^{2+}	*$BaCrO_4$	1.2×10^{-10}	Mg^{2+}	$MgCO_3$	6.8×10^{-6}
	$BaCO_3$	2.6×10^{-9}		MgF_2	5.2×10^{-11}
	BaF_2	1.8×10^{-7}		$Mg(OH)_2$	5.6×10^{-12}
	*$BaSO_4$	1.1×10^{-10}	Mn^{2+}	$MnCO_3$	2.3×10^{-11}
Ca^{2+}	$CaCO_3$ (calcite)	3.4×10^{-9}		*$Mn(OH)_2$	1.9×10^{-13}
	*CaF_2	5.3×10^{-11}	Hg_2^{2+}	*Hg_2Br_2	6.4×10^{-23}
	*$Ca(OH)_2$	5.5×10^{-5}		Hg_2Cl_2	1.4×10^{-18}
	$CaSO_4$	4.9×10^{-5}		*Hg_2I_2	2.9×10^{-29}
$Cu^{+,2+}$	$CuBr$	6.3×10^{-9}		Hg_2SO_4	6.5×10^{-7}
	CuI	1.3×10^{-12}	Ni^{2+}	$NiCO_3$	1.4×10^{-7}
	$Cu(OH)_2$	2.2×10^{-20}		$Ni(OH)_2$	5.5×10^{-16}
	$CuSCN$	1.8×10^{-13}	Ag^+	*$AgBr$	5.4×10^{-13}
Au^+	$AuCl$	2.0×10^{-13}		*$AgBrO_3$	5.4×10^{-5}
Fe^{2+}	$FeCO_3$	3.1×10^{-11}		$AgCH_3CO_2$	1.9×10^{-3}
	$Fe(OH)_2$	4.9×10^{-17}		$AgCN$	6.0×10^{-17}
Pb^{2+}	$PbBr_2$	6.6×10^{-6}		Ag_2CO_3	8.5×10^{-12}
	$PbCO_3$	7.4×10^{-14}		*$Ag_2C_2O_4$	5.4×10^{-12}
	$PbCl_2$	1.7×10^{-5}		*$AgCl$	1.8×10^{-10}
	$PbCrO_4$	2.8×10^{-13}		Ag_2CrO_4	1.1×10^{-12}
	PbF_2	3.3×10^{-8}		*AgI	8.5×10^{-17}
	PbI_2	9.8×10^{-9}		$AgSCN$	1.0×10^{-12}
	$Pb(OH)_2$	1.4×10^{-15}		*Ag_2SO_4	1.2×10^{-5}
	$PbSO_4$	2.5×10^{-8}			

TABEL 4: Suur en Basiese Eienskappe van Sommige Ione in Waterige Oplossing.

TABLE 4: Acid and Base Properties of Some Ions in Aqueous Solution.

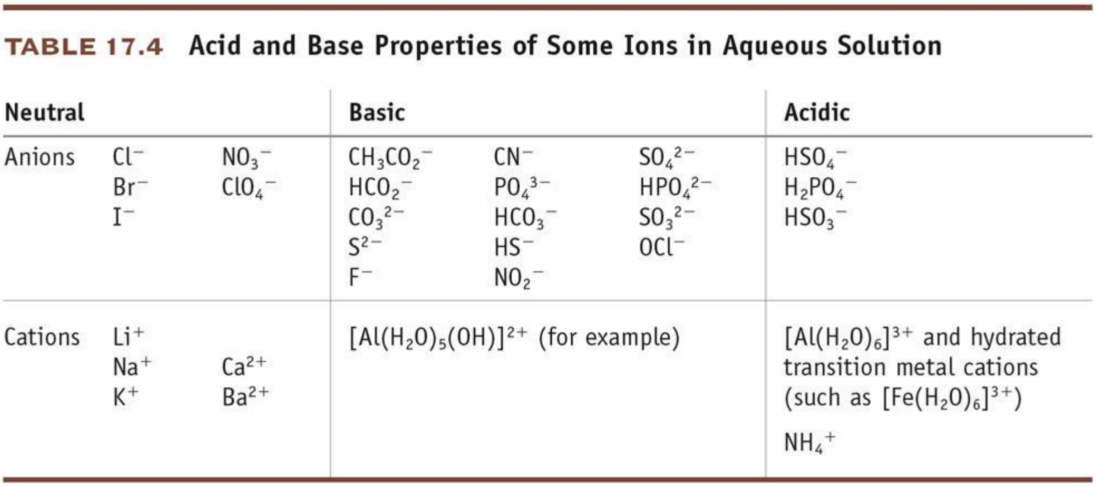
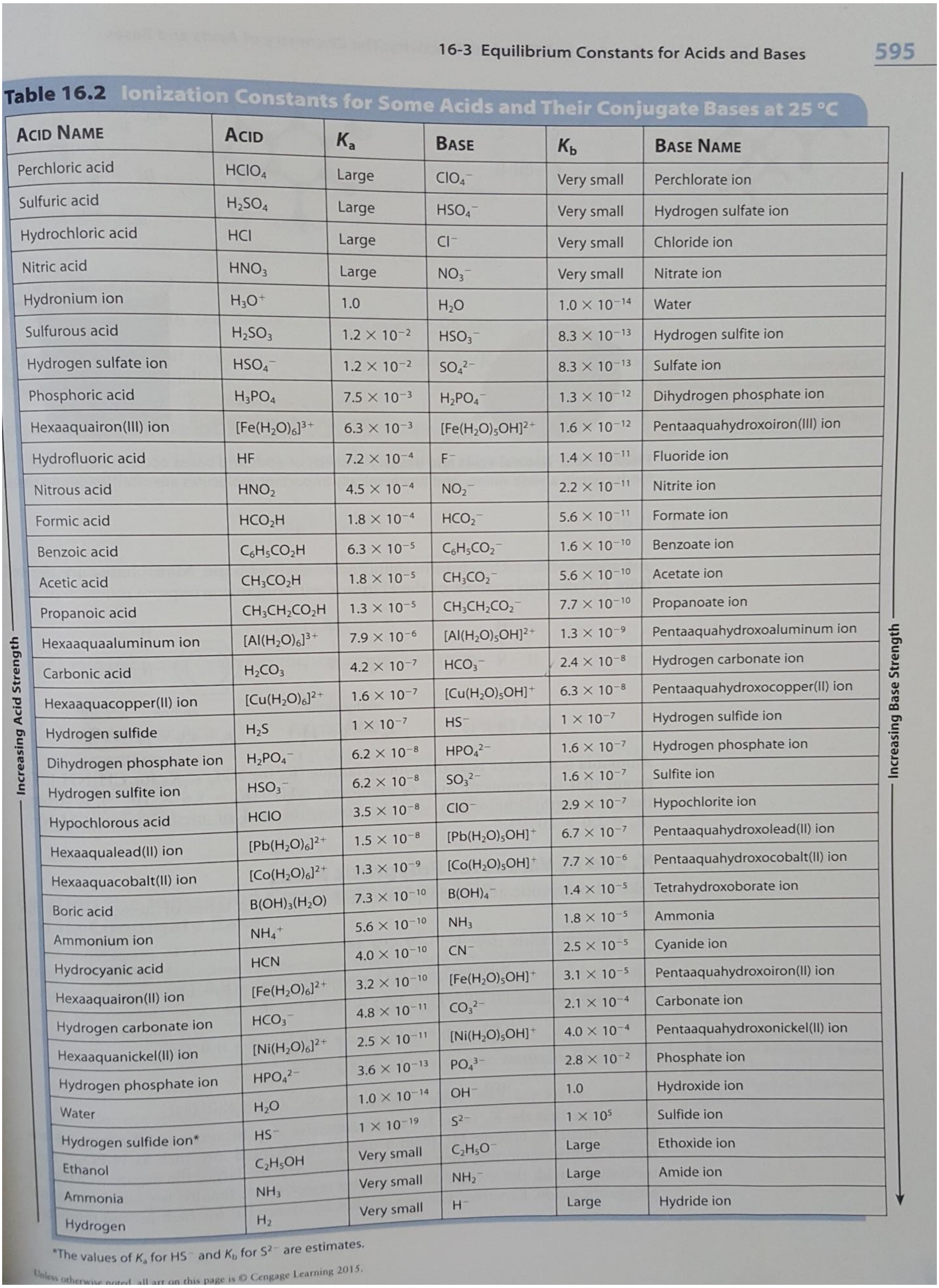


TABLE 17.4 **Acid and Base Properties of Some Ions in Aqueous Solution**

Neutral			Basic			Acidic
Anions	Cl^-	NO_3^-	$CH_3CO_2^-$	CN^-	SO_4^{2-}	HSO_4^-
	Br^-	ClO_4^-	HCO_2^-	PO_4^{3-}	HPO_4^{2-}	$H_2PO_4^-$
	I^-		CO_3^{2-}	HCO_3^-	SO_3^{2-}	HSO_3^-
			S^{2-}	HS^-	OCl^-	
			F^-	NO_2^-		
Cations	Li^+		$[Al(H_2O)_5(OH)]^{2+}$ (for example)			$[Al(H_2O)_6]^{3+}$ and hydrated transition metal cations (such as $[Fe(H_2O)_6]^{3+}$) NH_4^+
	Na^+	Ca^{2+}				
	K^+	Ba^{2+}				

TABEL 5: Ionisasiekonstantes vir sommige sure en hul gekonjugeerde basisse by 25 ^{o}C.

TABLE 5: Ionization constants for some acids and their conjugated bases at 25 ^{o}C.



16-3 Equilibrium Constants for Acids and Bases 595

Table 16.2 Ionization Constants for Some Acids and Their Conjugate Bases at 25 °C

ACID NAME	ACID	K_a	BASE	K_b	BASE NAME
Perchloric acid	$HClO_4$	Large	ClO_4^-	Very small	Perchlorate ion
Sulfuric acid	H_2SO_4	Large	HSO_4^-	Very small	Hydrogen sulfate ion
Hydrochloric acid	HCl	Large	Cl^-	Very small	Chloride ion
Nitric acid	HNO_3	Large	NO_3^-	Very small	Nitrate ion
Hydronium ion	H_3O^+	1.0	H_2O	1.0×10^{-14}	Water
Sulfurous acid	H_2SO_3	1.2×10^{-2}	HSO_3^-	8.3×10^{-13}	Hydrogen sulfite ion
Hydrogen sulfate ion	HSO_4^-	1.2×10^{-2}	SO_4^{2-}	8.3×10^{-13}	Sulfate ion
Phosphoric acid	H_3PO_4	7.5×10^{-3}	$H_2PO_4^-$	1.3×10^{-12}	Dihydrogen phosphate ion
Hexaaquairon(III) ion	$[Fe(H_2O)_6]^{3+}$	6.3×10^{-3}	$[Fe(H_2O)_5OH]^{2+}$	1.6×10^{-12}	Pentaaquahydroxoiron(III) ion
Hydrofluoric acid	HF	7.2×10^{-4}	F^-	1.4×10^{-11}	Fluoride ion
Nitrous acid	HNO_2	4.5×10^{-4}	NO_2^-	2.2×10^{-11}	Nitrite ion
Formic acid	HCO_2H	1.8×10^{-4}	HCO_2^-	5.6×10^{-11}	Formate ion
Benzoic acid	$C_6H_5CO_2H$	6.3×10^{-5}	$C_6H_5CO_2^-$	1.6×10^{-10}	Benzoate ion
Acetic acid	CH_3CO_2H	1.8×10^{-5}	$CH_3CO_2^-$	5.6×10^{-10}	Acetate ion
Propanoic acid	$CH_3CH_2CO_2H$	1.3×10^{-5}	$CH_3CH_2CO_2^-$	7.7×10^{-10}	Propanoate ion
Hexaaqualuminum ion	$[Al(H_2O)_6]^{3+}$	7.9×10^{-6}	$[Al(H_2O)_5OH]^{2+}$	1.3×10^{-9}	Pentaaquahydroxoaluminum ion
Carbonic acid	H_2CO_3	4.2×10^{-7}	HCO_3^-	2.4×10^{-8}	Hydrogen carbonate ion
Hexaaquacopper(II) ion	$[Cu(H_2O)_6]^{2+}$	1.6×10^{-7}	$[Cu(H_2O)_5OH]^+$	6.3×10^{-8}	Pentaaquahydroxocopper(II) ion
Hydrogen sulfide	H_2S	1×10^{-7}	HS^-	1×10^{-7}	Hydrogen sulfide ion
Dihydrogen phosphate ion	$H_2PO_4^-$	6.2×10^{-8}	HPO_4^{2-}	1.6×10^{-7}	Hydrogen phosphate ion
Hydrogen sulfite ion	HSO_3^-	6.2×10^{-8}	SO_3^{2-}	1.6×10^{-7}	Sulfite ion
Hypochlorous acid	$HClO$	3.5×10^{-8}	ClO^-	2.9×10^{-7}	Hypochlorite ion
Hexaaqualead(II) ion	$[Pb(H_2O)_6]^{2+}$	1.5×10^{-8}	$[Pb(H_2O)_5OH]^+$	6.7×10^{-7}	Pentaaquahydroxolead(II) ion
Hexaaquacobalt(II) ion	$[Co(H_2O)_6]^{2+}$	1.3×10^{-9}	$[Co(H_2O)_5OH]^+$	7.7×10^{-6}	Pentaaquahydroxocobalt(II) ion
Boric acid	$B(OH)_3(H_2O)$	7.3×10^{-10}	$B(OH)_4^-$	1.4×10^{-5}	Tetrahydroxoborate ion
Ammonium ion	NH_4^+	5.6×10^{-10}	NH_3	1.8×10^{-5}	Ammonia
Hydrocyanic acid	HCN	4.0×10^{-10}	CN^-	2.5×10^{-5}	Cyanide ion
Hexaaquairon(II) ion	$[Fe(H_2O)_6]^{2+}$	3.2×10^{-10}	$[Fe(H_2O)_5OH]^+$	3.1×10^{-5}	Pentaaquahydroxoiron(II) ion
Hydrogen carbonate ion	HCO_3^-	4.8×10^{-11}	CO_3^{2-}	2.1×10^{-4}	Carbonate ion
Hexaaquanickel(II) ion	$[Ni(H_2O)_6]^{2+}$	2.5×10^{-11}	$[Ni(H_2O)_5OH]^+$	4.0×10^{-4}	Pentaaquahydroxonickel(II) ion
Hydrogen phosphate ion	HPO_4^{2-}	3.6×10^{-13}	PO_4^{3-}	2.8×10^{-2}	Phosphate ion
Water	H_2O	1.0×10^{-14}	OH^-	1.0	Hydroxide ion
Hydrogen sulfide ion*	HS^-	1×10^{-19}	S^{2-}	1×10^5	Sulfide ion
Ethanol	C_2H_5OH	Very small	$C_2H_5O^-$	Large	Ethoxide ion
Ammonia	NH_3	Very small	NH_2^-	Large	Amide ion
Hydrogen	H_2	Very small	H^-	Large	Hydride ion

Increasing Acid Strength

Increasing Base Strength

*The values of K_a for HS^- and K_b for S^{2-} are estimates.