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

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 1e geleentheid Exam 1st opportunity Vraestel/Paper 1**	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:	**111**
Eksaminator(e)/ Examiner(s):	**Dr C.E. Read**	Datum/ Date:	**22/06/2017**
	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 Toon die aantal protone, neutron en elektrone in die volgende verbindings of ione aan. / *Indicate the number of protons, neutrons and electrons in the following compounds or ions.* **[5]**

Chemiese stof. *Chemical substance.*	**Protone. / *Protons.***	**Neutrone. / *Neutrons.***	**Elektrone. / *Electrons.***	
Ba^{2+}	**56**	**81**	**54**	✓
N^{3-}	**7**	**7**	**10**	✓
Co^{3+}	**27**	**32**	**24**	✓
Te^{2-}	**52**	**76**	**54**	✓
^{235}U	**92**	**143**	**92**	✓

Memo

Studente moet hele ry korrek antwoord voordat een punt per ry toegeken word.

1.2 Wat is die formules van die verbindings wat ooreenstem met die gegewe name in die tabel. / *What are the formulas of the compounds that correspond to the names given in the following table:* **[5]**

Naam van verbinding. / *Compound name.*	**Formule. / *Formula.***
Koolstoftetrabromied. / *Carbon tetrabromide.*	CBr_4 ✓
Kobalt(II)fosfaat. / *Cobalt(II) phosphate.*	$Co_3(PO_4)_2$ ✓
Magnesiumchloried. / *Magnesium chloride.*	$MgCl_2$ ✓
Nikkel(II)asetaat. / *Nickel(II) acetate.*	$Ni(CH_3COO)_2$ ✓
Kalsiumnitriet. / *Calcium nitrite.*	$Ca(NO_2)_2$ ✓

Vraag 2. / *Question 2.* **[10 PUNTE. / *10 MARKS*.]**

CHEMIESE REAKSIES. / *CHEMICAL REACTIONS.*

2.1 (i) Voorspel die produkte vir die volgende reaksie en dui aan in watter toestand (aq, s, ℓ, g) dit voorkom. (ii) Balanseer hierdie vergelyking, en (iii) gee ook die netto ioniese vergelyking. / *(i) Predict the product for the following reaction and show in what state (aq, s, ℓ, g) they occur. (ii) Balance the equation, and (iii) give the net ionic equation.* **[3]**

Reagense. / *Reagents.*		Produkte. / *Products.*
___$Pb(NO_3)_2$(aq) + $\underline{2}$ KBr(aq) ✓	→	**$PbBr_2$(s) + 2KNO_3(aq)** ✓
Netto Vergelyking. / *Net Equation.* **Pb^{2+}(aq) + 2Br^-(aq)**	→	**$PbBr_2$(s)** ✓

2.2 Bepaal die oksidasietoestand vir elk van die elemente in die volgende verbinding. Slegs die eenvoudigste heelgetalle sal aanvaar word. / *Determine the oxidation state for each of the elements in the following compound. Only the simplest integers will be accepted.* **[3]**

Verbinding. / *Compound.*	Oksidasietoestand. / *Oxidation State.*		
	Cu	Mn	O
Cu_2MnO_4	**+1** ✓	**+6** ✓	**-2** ✓

2.3 Klassifiseer die volgende reaksies as of oksidasie-reduksie of presipitasie of suur-basis reaksies. *Classify the following reactions as either oxidation-reduction or precipitation or acid-base reactions.* **[4]**

Reaksie. / *Reaction.*	Klassifikasie. / *Classification.*
Ca(s) + 2H_2O(ℓ) → $Ca(OH)_2$(s) + H_2(g)	**Oksidasie-reduksie** ✓
$Zn(OH)_2$(s) + H_2SO_4(ag) → $ZnSO_4$(aq) + 2H_2O(ℓ)	**Suur-basis** ✓
$CdCl_2$(aq) + Na_2S(aq) → CdS(s) + 2NaCl(aq)	**Presipitasie** ✓
C_2H_4(g) + 3O_2(g) → 2CO_2(g) + 2H_2O(g)	**Oksidasie-reduksie** ✓

Vraag 3. / *Question 3.* **[12 PUNTE. / *12 MARKS*.]**

STOIGIOMETRIE. / *STOICHIOMETRY.*

Oorweeg om koper(II)sulfaat met yster te reageer. Twee moontlike reaksies, voorgestel deur die volgende reaksies, kan plaasvind. / *Consider reacting copper(II) sulfate with iron. Two possible reactions can occur, as represented by the following equations*:

(1) Koper(II)sulfaat(aq) + yster(s) → koper(s) + yster(II)sulfaat(aq)
copper(II) sulfate(aq) + iron(s) → copper (s) + iron(II) sulfate(aq)
(2) Koper(II)sulfaat(aq) + yster(s) → koper(s) + yster(III)sulfaat(aq)
copper(II) sulfate(aq) + iron(s) → copper (s) + iron(III) sulfate(aq)

Jy plaas 87.7 mL van 'n 0.500 M oplossing van koper(II)sulfaat in 'n beker. Dan gooi jy 2.00 g yster vylsels by die koper(II)sulfaat-oplossing. Nadat die reaksie plaasgevind het, isoleer jy 2.27 g koper. Watter een van die twee vergelykings hierbo beskryf die reaksie wat plaasgevind het? Staaf you antwoord met berekeninge.

You place 87.7 mL of a 0.500 M solution of copper(II) sulfate in a beaker. You then add 2.00 g of iron filings to the copper(II) sulfate solution. After the reaction occurs, you isolate 2.27 g of copper. Which equation above describes the reaction that occurred? Support your answer with calculations. **[12]**

(1) $CuSO_4(aq) + Fe(s) \rightarrow Cu(s) + FeSO_4(aq)$ ☑
(2) $3CuSO_4(aq) + 2Fe(s) \rightarrow 3Cu(s) + Fe_2(SO_4)_3(aq)$ ☑
Mol $CuSO_4$ = n = CV = 0.500 x 0.0877 = 0.04385 mol ☑
The mol Fe = n = m/M = 2.00/ 55.85 = 0.03581 mol ☑
Mole ratio (Cu/Fe) balanced equation 1 = 1/1 NEED (1) ☑
Mole ratio (Cu/Fe) balanced equation 2 = 3/2 = 1.5/1 NEED (2) ☑
Mole ratio (Cu/Fe) calculated moles = 0.04385/0.03581 = 1.225/1 HAVE ☑

ONLY equation (1) can work where Cu(II) sulfate is the excess reagent and iron is the limiting reagent ☑

<u>For equation (2)</u>

Mol $CuSO_4$ = 3x = 0.04385 mol mass = nM = 0.04385 x 159.55 = 6.996 g
Mol Fe = 2x = 0.02923 mol ☑ mass = 0.02923 x 55.85 = 1.632 g ☑
Mol Cu = 3x = 0.04385 mol ☑ mass = 0.04385 x 63.55 = 2.787 g ☑
Mol $Fe_2(SO_4)_3$ = x = 0.01462 mol mass = 0.01462 x 399.7 = 5.844 g
$CuSO_4$ is the limiting reagent ☑
Fe is the excess reagent [You have 2.00 g and uses 1.632 g] ☑
Cu theoretical yield is 2.787 g
Cu actual yield is 2.27 g
% yield is (2.27/2.787) x 100 = 81.45% ☑

<u>For equation (1)</u>

If $CuSO_4$ is the excess reagent and Fe the limiting reagent:

The mol Fe = n = m/M = 2.00/ 55.85 = 0.03581 mol

Mol $CuSO_4$ = x = 0.03581 mol		mass = nM = 0.03581 x 159.55 = 5.713 g	
Mol Fe = x = 0.03581 mol	☑	mass = 0.03581 x 55.85 = 2.000 g	☑
Mol Cu = x = 0.03581 mol	☑	mass = 0.03581 x 63.55 = 2.276 g	☑
Mol $FeSO_4$ = x = 0.03581 mol		mass = 0.03581 x 151.85 = 5.438 g	

Vraag 4. / *Question 4.* **[8 PUNTE. / *8 MARKS*.]**

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

1.1 'n Monster van nikkel word verhit tot 99.8^{0}C en geplaas in 'n koffiekoppie kalorimeter wat 150.0 g water bevat by 23.5^{0}C. Nadat die metaal afgekoel het, is die finale temperatuur van die metaal en water mengsel 25.0^{0}C . As die spesifieke hittekapasiteit van nikkel 0.444 J/g.^{0}C is, watter massa nikkkel is oorspronklik verhit? Die spesifieke hittekapasiteit van water is *4.18 J/g.K.* Veronderstel dat geen hitte verloor word na die omgewing nie. / *A sample of nickel is heated to 99.8^{0}C and placed in a coffee cup calorimeter containing 150.0 g water at 23.5^{0}C. After the metal cools, the final temperature of the metal and water mixture is 25.0^{0}C. If the specific heat capacity of nickel is 0.444 J/g.^{0}C, what mass of nickel was originally heated? The specific heat capacity of water is 4.18 J/g.K.* Assume no heat loss to the surroundings. **[3]**

$q_{ni} + q_w = 0$ ☑

$(mC\Delta T)_{ni} + (mC\Delta T)w = 0$

(m x 0.444 x (-74.8)) + (150.0 x 4.18 x (1.5)) = 0 ☑

m (-33.211) + (940.5) = 0

m = 940.5/33.211 = 28.318 g ☑

4.2 Die vriespunt van kwik is -38.8^{0}C. Hoeveel energie, in joules, word vrygestel aan die omgewing as 5.00 mL kwik afgekoel word vanaf 20^{0}C to -38.8^{0}C en dan gevries word tot 'n vastestof. (Die digtheid van die kwik vloeistof is 13.6 g/cm^3. Die spesifieke hittekapasiteit is 0.140 J/g.K en die hitte van fusie is 11.4 J/g.) / *The freezing point of mercury is -38.8^{0}C. What quantity of energy, in joules, is released to the surroundings if 5.00 mL of mercury is cooled from 20^{0}C to -38.8^{0}C and then frozen to a solid? (The density of the liquid mercury is 13.6 g/cm^3. Its specific heat capacity is 0.140 J/g.K and its heat of fusion is 11.4 J/g.)* **[3]**

D = m/V thus mass = DV = 13.6 x 5 = 68.00 g

$q_1 = mC\Delta T$ = 68 x 0.140 x (-58.8) = -559.776 J☑

$q_2 = \Delta H_{fus}$ x m = -11.4 J/g x 68 = -775.2 J ☑

$q_{total} = q_1 + q_2$ = -559.776 -775.2 = -1334.976 Joule ☑

4.3 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.

✓✓

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

CHEMIESE EWEWIG. / *CHEMICAL EQUILIBRIUM.*

5.1 Die volgende ewewigskonsentrasies by 127^0C word waargeneem vir die Haber-proses: / *The following equilibrium concentrations were observed for the Haber process at 127^0C:* **[6]**

$[NH_3] = 3.1 \times 10^{-2}$ mol/L

$[N_2] = 8.5 \times 10^{-1}$ mol/L

$[H_2] = 3.1 \times 10^{-3}$ mol/L

5.1.1 Bereken die waarde van K_1 by 127^0C vir die reaksie van die Haberproses. / *Calculate the value of K_1 at 127^0C for the reaction of the Haber process.*

$N_2(g) + 3H_2(g) \leftrightarrows 2NH_3(g)$ ☑ the Haber process

$K_1 = [NH_3]^2 / ([N_2]\ [H_2]^3) = (3.1 \times 10^{-2})^2 / (8.5 \times 10^{-1} \times (3.1 \times 10^{-3})^3) = 3.7950 \times 10^4\ L^2/mol^2$ ☑ **The student does not have to give the unit.**

5.1.2 Bereken die waarde van die ewewigkonstante, K_2, by 127^0C vir die volgende reaksie. *Calculate the value of the equilibrium constant, K_2, at 127^0C for the following reaction:*

$$2NH_3(g) \leftrightarrows N_2(g) + 3H_2(g)$$

$2NH_3(g) \leftrightarrows N_2(g) + 3H_2(g)$ the reverse reaction of (a) thus $K_2 = 1/K_1$ ☑

$K_2 = 1/(3.7950 \times 10^4) = 2.635 \times 10^{-5}\ mol^2/L^2$ ☑ **The student does not have to give the unit.**

5.1.3 Bereken die waarde van die ewewigkonstante, K_3, by 127^0C vir die reaksie wat gegee word deur die vergelyking: / *Calculate the value of the equilibrium constant, K_3, at 127^0C for the reaction given by the equation:*

$$\tfrac{1}{2}N_2(g) + 3/2H_2(g) \leftrightarrows NH_3(g)$$

$\tfrac{1}{2}N_2(g) + 3/2H_2(g) \leftrightarrows NH_3(g)$ this reaction is (5.1.1) x ½] thus $K_3 = (K_1)^{½}$ ☑

$K_3 = (3.7950 \times 10^4)^{½} = 194.808$ L/mol ☑ **The student does not have to give the unit.**

5.2 Gasagtige NOCl ontbind om die gasse NO en Cl_2 te vorm. By 35^0C is die ewewigskonstante 1.6×10^{-5} mol. Wat is die ewewigskonsentrasies wanneer 1.0 mol NOCl in ‘n 2.0 liter fles geplaas word? *Gaseous NOCl decomposes to form the gases NO and Cl_2. At 35^0C the equilibrium constant is 1.6×10^{-5} mol/L. When 1.0 mol NOCl is placed in a 2.0 liter flask, what are the equilibrium concentrations?* **[6]**

$2NOCl(g) \leftrightarrows 2NO(g) + Cl_2(g)$ ☑

$K = [NO]^2 [Cl_2] / [NOCl]^2 = 1.6 \times 10^{-5}$ mol/L and $[NOCl] = ½ = 0.50$ mol/L ☑

	NOCl	NO	Cl_2
[Initial]	0.5	0	0
[change]	-2x	+2x	+x
[Equilibrium]	(0.5 – 2x)	2x	x
	0.48	2.0×10^{-2}	1.0×10^{-2}

One mark for table and one marks for equilibrium concentrations. ☑☑

$K = [NO]^2 [Cl_2] / [NOCl]^2 = (2x)^2(x) / (0.5 – 2x)^2$ ☑

[initial] / K >> 100 thus $0.5 / 1.6 \times 10^{-5} = 31250 > 100$ the x in (0.5 – 2x) can be ignored

$K = [NO]^2 [Cl_2] / [NOCl]^2 = (2x)^2(x) / (0.5)^2 = 4x^2 (x) / 0.25 = 1.6 \times 10^{-5}$

$X^3 = 1.0 \times 10^{-6}$ $x = 1.0 \times 10^{-2}$ ☑

5.3 Wat is die verskil tussen die ewewigskonstante en die reaksiekwosient? / *What is the difference between the equilibrium constant and the reaction quotient?* **[2]**

$aA + bB \leftrightarrows cC + dD$ $K = ([A]^a [B]^b) / ([C]^c [D]^d)$ and $Q = ([A]^a [B]^b) / ([C]^c [D]^d)$

Both are determined with the same equation BUT K with equilibrium concentrations ☑ and Q with given concentrations to determine whether a reaction is at equilibrium, moving towards equilibrium or is past equilibrium ☑.

5.4 Hoekom word gesê dat chemiese ewewigte in ‘n dinamiese toestand is? / *Why are chemical equilibria said to be in a dynamic state?* **[1]**

a. omrede die reagens konsentrasie stadig oor tyd afneem. / *because the reactant concentration decreases slowly over time.*

b. omrede die omgekeerde reaksie enige tyd dominant kan word. / *because the reverse reaction could become dominant at any moment.*

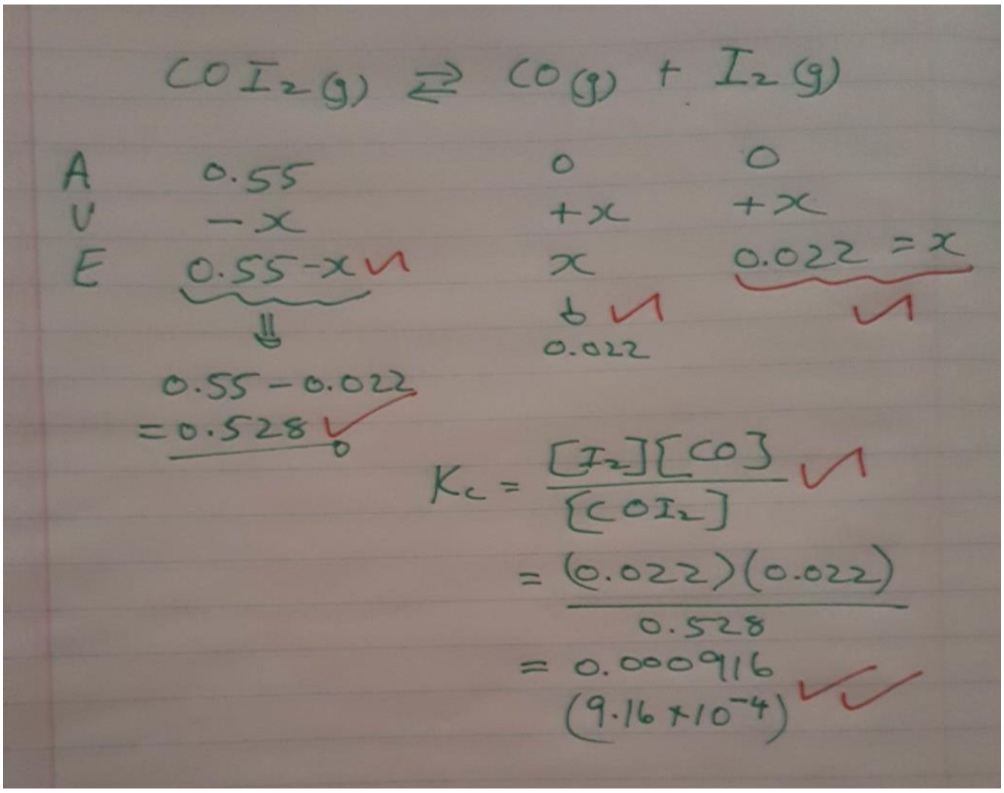
c. omrede die konsentrasies van al die chemiese spesies nie verander nie. / *because the concentrations of all chemical species do not change.*

[✓ **d.**] **omrede die voorwaartse en terugwaartse reaksies teen dieselfde tempo aanhou. / *because the forward and reverse reactions continue to occur at equal rates.***

5.5 0.55 M COI_2 word aanvanklik in 'n 2.00 L fles verhit en die reaksie word toegelaat om ewewig te bereik. By ewewig is die konsentrasie I_2 gelyk aan 0.022 M. Bereken die ewewigskonstante, K_c, vir die reaksie.

0.55 M of COI_2 is heated initially in a 2.00 L flask and the reaction is left to reach equilibrium. At equilibrium the concentration of I_2 is equal to 0.022 M. Calculate the equilibrium constant, K_c, for the reaction. **[5]**

$$COI_2(g) \rightleftharpoons CO(g) + I_2(g)$$



$COI_2(g) \rightleftharpoons CO(g) + I_2(g)$

A	0.55	0	0
V	−x	+x	+x
E	0.55−x ✓	x	0.022 = x ✓
	⇓	⇓ ✓	✓
	0.55 − 0.022 = 0.528 ✓	0.022	

$$K_c = \frac{[I_2][CO]}{[COI_2]} \checkmark = \frac{(0.022)(0.022)}{0.528} = 0.000916 \; (9.16 \times 10^{-4}) \checkmark\checkmark$$

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

SURE EN BASISSE. / *ACIDS AND BASES.*

6.1 Bereken die persentasie piridien (C_5H_5N) wat die piridinium ioon, $C_5H_5NH^+$, vorm in 'n 0.10 M waterige piridien oplossing ($K_b = 1.7 \times 10^{-9}$). Wat is die pH van die oplossing? / *Calculate the percentage of pyridine (C_5H_5N) that forms pyridinium ion, $C_5H_5NH^+$, in a 0.10 M aqueous solution of pyridine ($K_b = 1.7 \times 10^{-9}$). What is the pH of the solution?* **[6]**

$C_5H_5N + H_2O \leftrightarrows C_5H_5NH^+ + OH^-$ ☑

$K_b = 1.7 \times 10^{-9} = [C_5H_5NH^+][OH^-] / [C_5H_5N]$

	$[C_5H_5N]$	$[C_5H_5NH^+]$	$[OH^-]$
[ini]	0.10	0	0
[ch]	-x	+x	+x
[eq]	0.1-x	x	x

☑ for correct table

$K_b = 1.7 \times 10^{-9} = [C_5H_5NH^+][OH^-] / [C_5H_5N] = x^2 / (0.10 - x)$ ☑

$[0.10] / 1.7 \times 10^{-9} >> 100$ thus $(0.10 – x) = (0.10)$

$x^2 = 1.7 \times 10^{-9} \times 0.10 = 1.7 \times 10^{-10}$ thus $x = 1.304 \times 10^{-5}$ ☑

% pyridine = (0.0999/0.10) x 100 = 99.9% ☑

pOH = -log $[OH^-]$ = 4.88 therefore pH = 14 – 4.88 = 9.12 ☑

6.2 Is oplossings van die volgende soute suur, basies of neutraal? Voltooi die volgende tabel en dui onder pH slegs aan of die pH < 7, pH > 7 of pH = 7 sal wees. Geen berekeninge is nodig nie.

Are solutions of the following salts acidic, basic, or neutral? Complete the following table and indicate under pH whether the pH will be pH < 7, pH > 7 or pH = 7. No calculations are necessary. **[5]**

Sout / *Salt*	**Sout reaksie in water / *Salt reaction in water***	**K**	**pH**
$Sr(NO_3)_2$	No reaction	K_a = very small ($< 10^{-14}$) K_b = very small ($< 10^{-14}$)	pH=7
$C_2H_5NH_3CN$	$C_2H_5NH_3^+ + H_2O \leftrightarrows$ $CN^- + H_2O \leftrightarrows HCN + OH^-$	$K_a = 1.78 \times 10^{-11}$ $K_b = 2.5 \times 10^{-5}$	pH > 7
C_5H_5NHF	$C_5H_5NH^+ + H_2O \leftrightarrows C_5H_5N + H_3O^+$ $F^- + H_2O \leftrightarrows$	$K_a = 5.88 \times 10^{-6}$ $K_b = 1.4 \times 10^{-11}$	pH < 7
$NH_4C_2H_3O_2$	$NH_4^+ + H_2O \leftrightarrows$ $CH_3COO^- + H_2O \leftrightarrows$ ions cancel each other out	$K_a = 5.6 \times 10^{-10}$ $K_b = 5.6 \times 10^{-10}$	pH = 7
$NaHCO_3$	$HCO_3^- + H_2O \leftrightarrows H_2CO_3 + OH^-$	K_a = very small ($< 10^{-14}$) $K_a = 4.8 \times 10^{-11}$ $K_b = 2.4 \times 10^{-8}$	pH > 7

Studente kry een punt vir 'n korrekte ry antwoorde

6.3 Identifiseer die suur-basis gekonjugeerde pare in die volgende reaksie. / *Identify the acid-base conjugated pairs in the following reaction.* **[2]**

$$HNO_3(aq) + NH_3(aq) \rightleftharpoons NH_4^+(aq) + NO_3^-(aq)$$

NH_3 = basis; NH_4^+ = gekonjugeerde suur. ✓

HNO_3 = suur; NO_3^- = gekonjugeerde basis. ✓

6.4 Bereken die hidroksiedioonkonsentrasie en die hidroniumioonkonsentrasie in 'n waterige 0.0012 M NaOH oplossing by 25°C. Die ioonproduk van water is: $K_w = 1.0 \times 10^{-14}$. / *Calculate the hydroxide ion concentration and the hydronium ion concentration in a 0.0012 M aqueous solution of NaOH at 25°C. The ion product of water is:* $K_w = 1.0 \times 10^{-14}$. **[2]**

0.0012 mol NaOH per liter = 0.0012 M $Na^+(aq)$ + 0.0012 M $OH^-(aq)$

DUS: $\underline{[OH^-] = 0.0012\ M}$ ✓

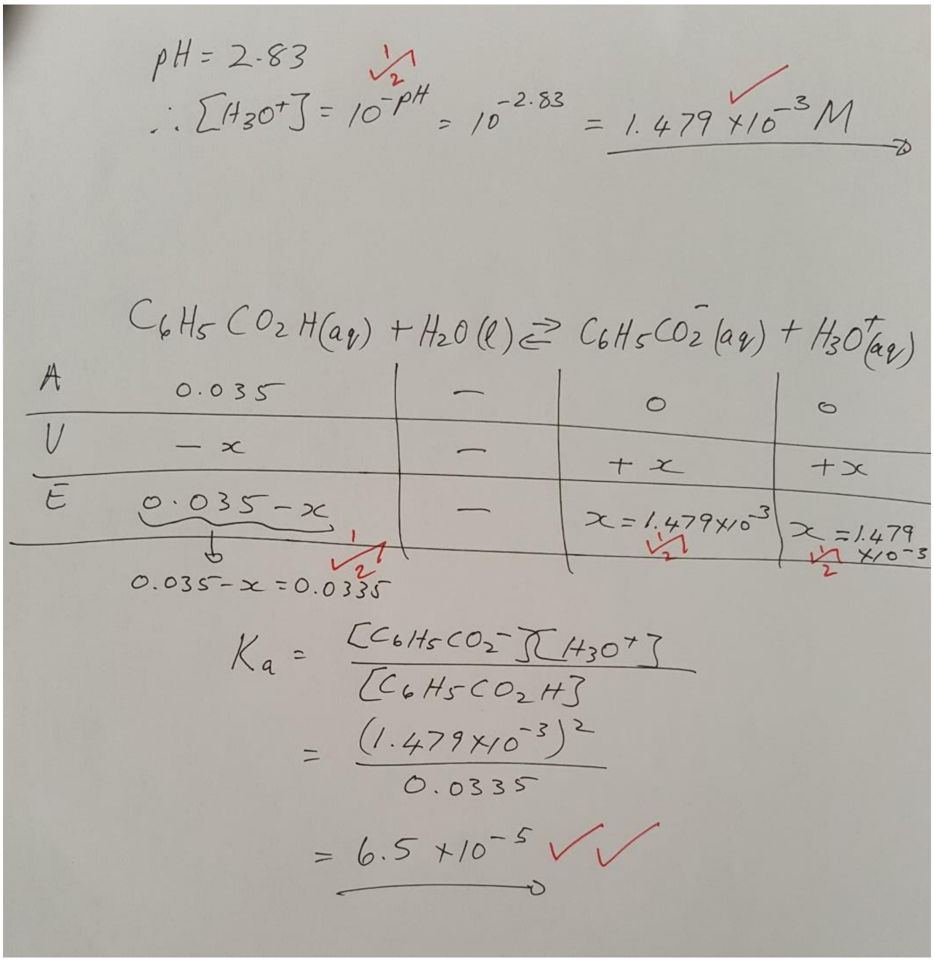
Vervang die OH^- konsentrasie in die volgende vergelyking in:

$K_w = [H_3O^+][OH^-] = 1.0 \times 10^{-14}$

$[H_3O^+] = 1.0 \times 10^{-14} / 0.0012 = \underline{8.3 \times 10^{-12}\ M}$ ✓

6.5 Bereken die K_a-waarde van 'n 0.035 M oplossing van bensoësuur ($C_6H_5CO_2H$) indien die pH van die oplossing gelyk aan 2.83 is. / *Calculate the K_a-value of a 0.035 M solution of benzoic acid ($C_6H_5CO_2H$) if the pH of the solution is equal to 2.83.* **[5]**

$$C_6H_5CO_2H(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + C_6H_5CO_2^-(aq)$$



$pH = 2.83$ $\frac{1}{2}$✓

$\therefore [H_3O^+] = 10^{-pH} = 10^{-2.83} = \underline{1.479 \times 10^{-3} M} \rightarrow$ ✓

$C_6H_5CO_2H(aq) + H_2O(l) \rightleftharpoons C_6H_5CO_2^-(aq) + H_3O^+(aq)$

A	0.035	–	0	0
U	– x	–	+ x	+ x
E	0.035 – x	–	x = 1.479×10⁻³ $\frac{1}{2}$✓	x = 1.479 ×10⁻³ $\frac{1}{2}$✓

$0.035 - x = 0.0335$ $\frac{1}{2}$✓

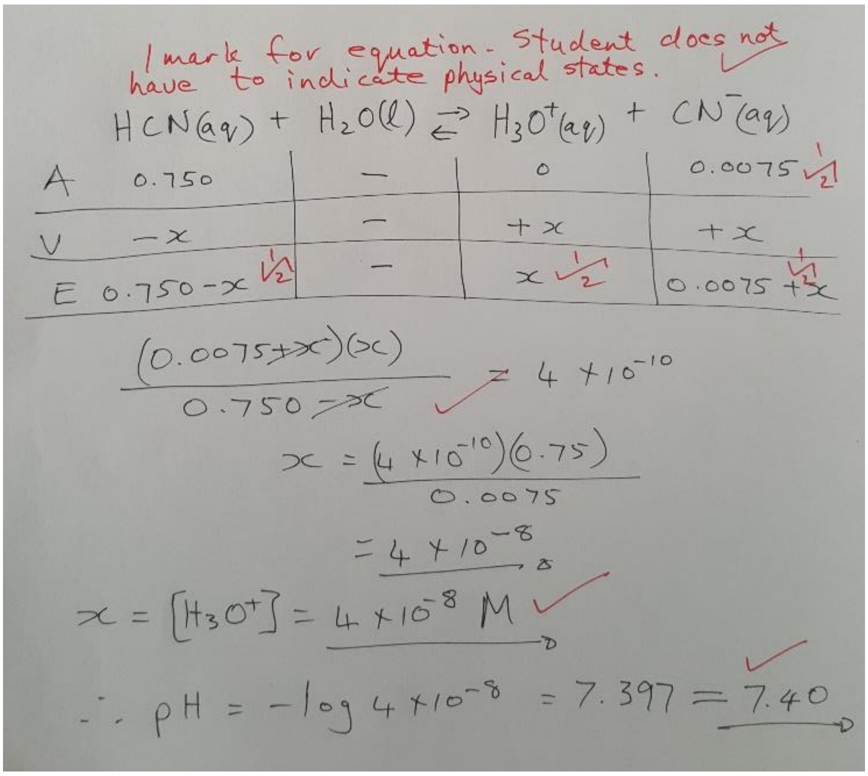
$$K_a = \frac{[C_6H_5CO_2^-][H_3O^+]}{[C_6H_5CO_2H]} = \frac{(1.479 \times 10^{-3})^2}{0.0335} = \underline{6.5 \times 10^{-5}} \rightarrow ✓✓$$

Vraag 7. / *Question 7.* **[31 PUNTE. / *31 MARKS.*]**

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

7.1 'n Waterige oplossing van 0.750 M HCN het 'n **pH van 4.76**. Bewys deur middel van 'n AVE tabel en berekeninge dat die pH van die oplossing **verander na 7.40** indien jy aanvanklik 0.0075 M se NaCN sou byvoeg. / *An aqueous solution of 0.750 M HCN has a **pH of 4.76**. Prove by using an ICE table and calculations that the pH of the solution **changes to 7.40** if you initially added 0.0075 M NaCN to the solution.* **[6]**

(**Gegee: / *Given:*** $K_a = 4.0 \times 10^{-10}$, $K_b = 2.5 \times 10^{-5}$, $K_w = 1.00 \times 10^{-14}$, $M_{HCN} = 27$ g.mol^{-1}, $M_{NaCN} = 49$ g.mol^{-1})



1 mark for equation. Student does not have to indicate physical states. ✓

$HCN(aq) + H_2O(\ell) \rightleftarrows H_3O^+(aq) + CN^-(aq)$

A	0.750	–	0	0.0075 ✓½
V	−x	–	+x	+x
E	0.750 − x ½	–	x ✓½	0.0075 + x ✓½

$$\frac{(0.0075 \cancel{+x})(x)}{0.750 \cancel{-x}} = 4 \times 10^{-10} \checkmark$$

$$x = \frac{(4 \times 10^{-10})(0.75)}{0.0075}$$

$$= \underline{4 \times 10^{-8}}$$

$$x = [H_3O^+] = \underline{4 \times 10^{-8}\ M} \checkmark$$

$$\therefore pH = -\log 4 \times 10^{-8} = 7.397 = \underline{7.40} \checkmark$$

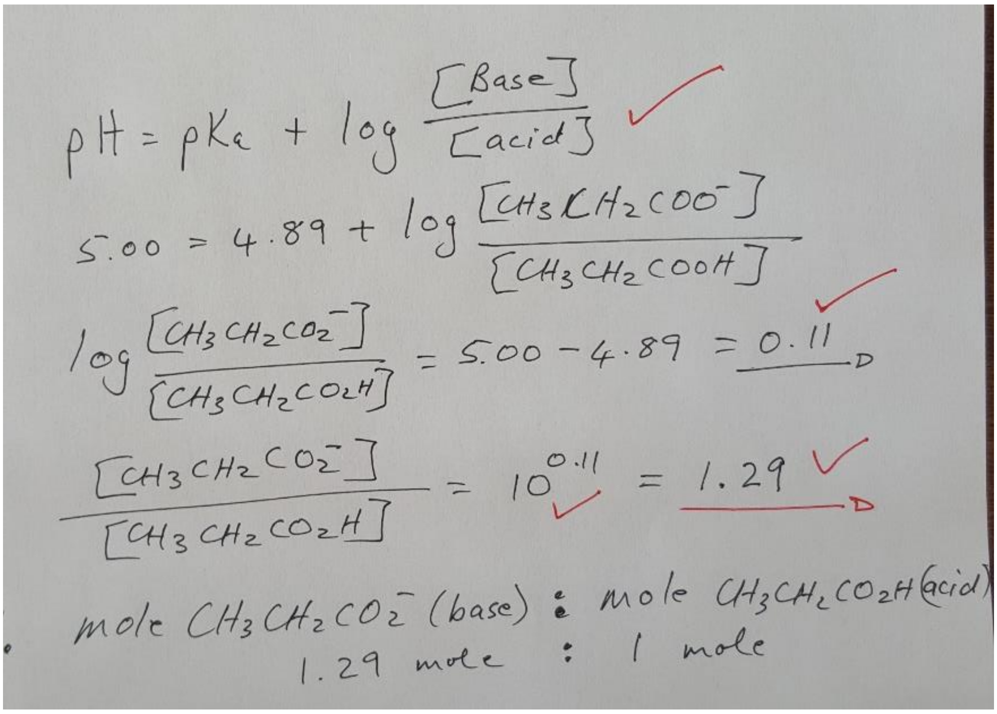
7.2 Jy wil 'n 1.00 L bufferoplossing met 'n pH van 5.00 voorberei. 'n Lys van moontlike sure (en die ooreenstemmende gekonjugeerde basisse) volg: / *You want to prepare a 1.00 L of buffer solution with a pH of 5.00. A list of possible acids (and the corresponding conjugated bases) follows:*

Suur: *Acid.*	Gekonjugeerde basis. *Conjugated base.*	K_a	pK_a
HCO_2H	HCO_2^-	1.8×10^{-4}	
CH_3CH_2COOH	$CH_3CH_2COO^-$	1.3×10^{-5}	
H_2CO_3	HCO_3^-	4.2×10^{-7}	
NH_4^+	NH_3	5.6×10^{-10}	
HPO_4^{2-}	PO_4^{3-}	3.6×10^{-13}	

7.2.1 Dui aan watter suur en gekonjugeerde basis paar gebruik gaan word om die bufferoplossing voor te berei. / *Indicate which acid and conjugate base pair will be used to prepare the buffer solution.* **[1]**

CH_3CH_2COOH en $CH_3CH_2COO^-$ ✓

7.2.2 Bereken die molverhouding tussen die suur en sy gekonjugeerde basis in vraag 7.2.1.
Calculate the mole ratio between the acid and its conjugate base in question 7.2 1. **[4]**



$$pH = pK_a + \log \frac{[Base]}{[acid]} \quad ✓$$

$$5.00 = 4.89 + \log \frac{[CH_3CH_2COO^-]}{[CH_3CH_2COOH]}$$

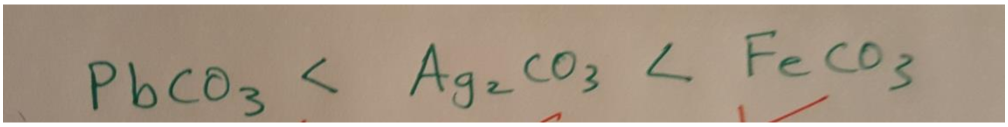
$$\log \frac{[CH_3CH_2CO_2^-]}{[CH_3CH_2CO_2H]} = 5.00 - 4.89 = \underline{0.11} \quad ✓$$

$$\frac{[CH_3CH_2CO_2^-]}{[CH_3CH_2CO_2H]} = 10^{0.11} ✓ = \underline{1.29} \quad ✓$$

mole $CH_3CH_2CO_2^-$ (base) : mole $CH_3CH_2CO_2H$ (acid)
1.29 mole : 1 mole

7.3 Plaas die verbindings $FeCO_3$, Ag_2CO_3 en $PbCO_3$ in volgorde van toenemende oplosbaarheid in water deur van die K_{sp}-waardes in Tabel 3 agter in die vraestel gebruik te maak en motiveer jou antwoord. *Rank the compounds $FeCO_3$, Ag_2CO_3 and $PbCO_3$ according to increasing solubility in water by using the K_{sp} values in Table 3 at the back of the paper and motivate your answer.* **[3]**

Minste oplosbaar. **Meeste oplosbaar.**
Least soluble. ***Most soluble.***



$PbCO_3 < Ag_2CO_3 < FeCO_3$

Ksp = 7.4×10^{-14} **Ksp = 8.5×10^{-12}** **Ksp = 3.1×10^{-11}**

The salt plus its Ksp value is one mark. The Ksp value is the motivation. Half a mark for the salt in the correct sequence and half a mark for the corresponding Ksp value.

7.4 Bereken die K_{sp} waarde vir bismutsulfied (Bi_2S_3), wat 'n oplosbaarheid van 1.0×10^{-15} mol/L by 25^0C het.

Calculate the K_{sp} value for bismuth sulfide (Bi_2S_3), which has a solubility of 1.0×10^{-15} mol/L at 25^0C.

[6]

$Bi_2S_3(s) \leftrightarrows 2Bi^{3+}(aq) + 3S^{2-}(aq)$ ☑

$K_{sp} = [Bi^{3+}]^2 [S^{2-}]^3$ ☑

Equilibrium concentration of $Bi_2S_3 = 1.0 \times 10^{-15}$ mol/L

Thus $[Bi^{3+}] = 2(1.0 \times 10^{-15}) = 2.0 \times 10^{-15}$ mol/L ☑

And $[S^{2-}] = 3(1.0 \times 10^{-15}) = 3.0 \times 10^{-15}$ mol/L ☑

$K_{sp} = [Bi^{3+}]^2 [S^{2-}]^3 = (2.0 \times 10^{-15})^2 (3.0 \times 10^{-15})^3$ ☑

$K_{sp} = 1.1 \times 10^{-73}$ ☑

7.5 'n Monster van 10.00 g wat bestaan uit 'n mengsel van natriumchloried en kaliumsulfaat word opgelos in water. Hierdie waterige oplossing reageer met oormaat lood(II)nitraat om 21.75 g vastestof te vorm. Bepaal die massa persentasie van die natriumchloried in die oorspronklike mengsel.

A 10.00 g sample consisting of a mixture of sodium chloride and potassium sulfate is dissolved in water. This aqueous mixture then reacts with excess aqueous lead(II) nitrate to form 21.75 g of solid. Determine the mass percent of sodium chloride in the original mixture. **[11]**

$2NaCl + Pb(NO_3)_2 \leftrightarrows PbCl_2(s) + 2NaNO_3$ ☑

$K_2SO_4 + Pb(NO_3)_2 \leftrightarrows PbSO_4(s) + 2KNO_3$ ☑

$xNaCl + yK_2SO_4 = 10$ gram ☑

x(58.45 g/mol) + y(174.2 g/mol) = 10 g ☑

$(x/2)PbCl_2(s) + yPbSO_4(s) = 21.75$ gram ☑

(x/2)(278.1 g/mol) + y(303.2 g/mol) = 21.75 g ☑

Thus

X = (10 – 174.2y) / 58.45 and

X = 2(21.75 – 303,2y) / 278.1

Then

(10 – 174.2y) / 58.45 = 2(21.75 – 303,2y) / 278.1 ☑

[multiply with 278.1] 4.7579(10 – 174.2y) = 2(21.75 – 303,2y)

47.579 – 43.50 = 828.828y – 606.40y

4.079 = 222.428y

Y = 4.079 / 222.428 = 0.01834 mol ☑

Thus x = (10 – 174.2{0.01834}) / 58.45 = (10 – 3,195) / 58.45 = 0.11643 mol ☑

Mass NaCl = nM = 0.11643 x 58.45 = 6.805 g ☑

Mass% NaCl = (6.805/10) x 100 = 68.05% ☑

Test: x$NaCl$ + yK_2SO_4 = 10 gram

x(58.45 g/mol) + y(174.2 g/mol) = 10 g

(0.11643 x 58.45) = (0.01834 x 174.2) = 10 g

6.805 + 3.195 = 10 gram

JY MAG BLADSYE 18 TOT 23 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 PAGES 18 TO 23 FOR 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 **Al** 27,0	atomic number / atoomgetal symbol / simbool 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.

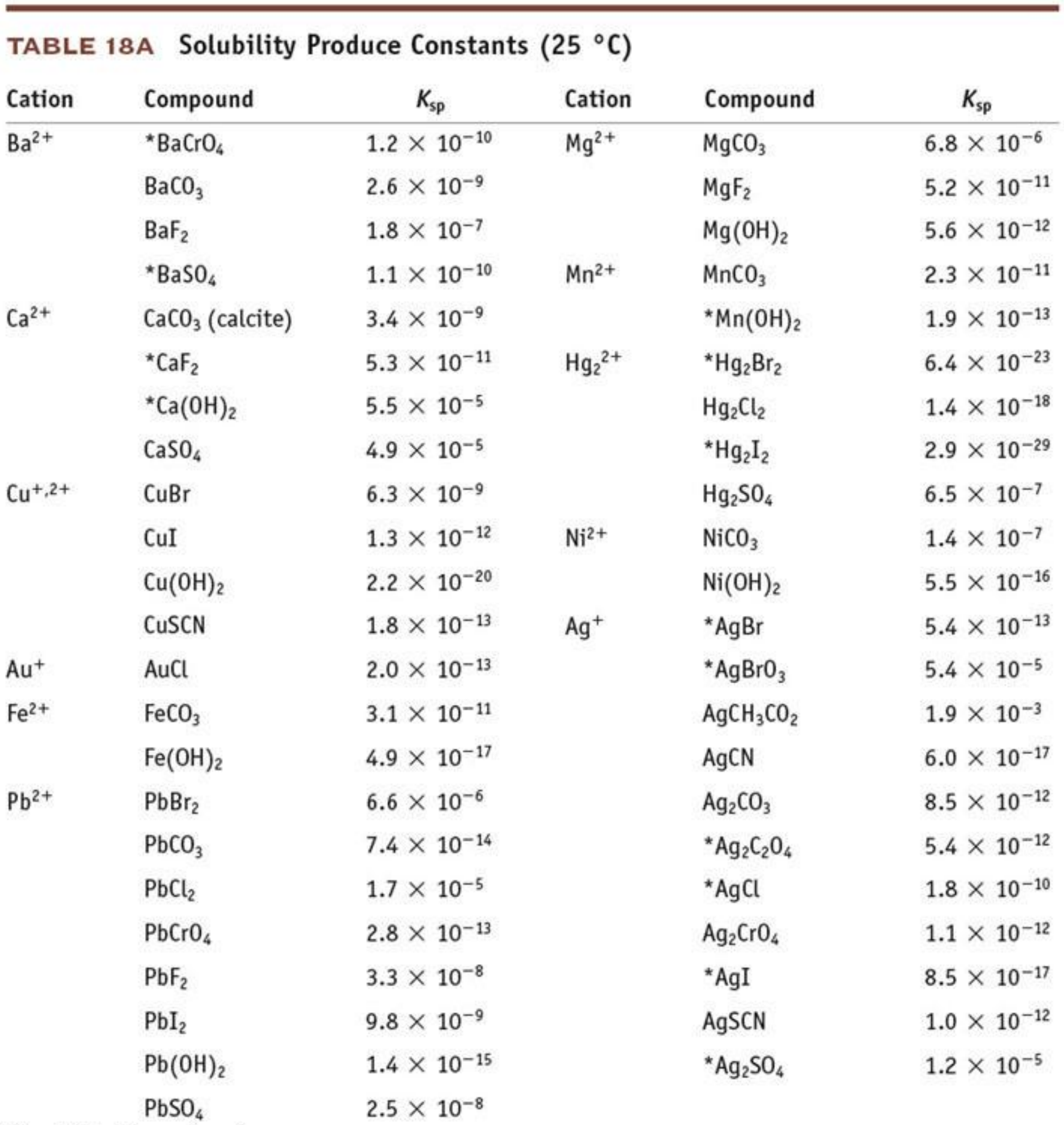


TABLE 18A Solubility Produce Constants (25 °C)

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}			

© Brooks/Cole, Cengage Learning

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

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

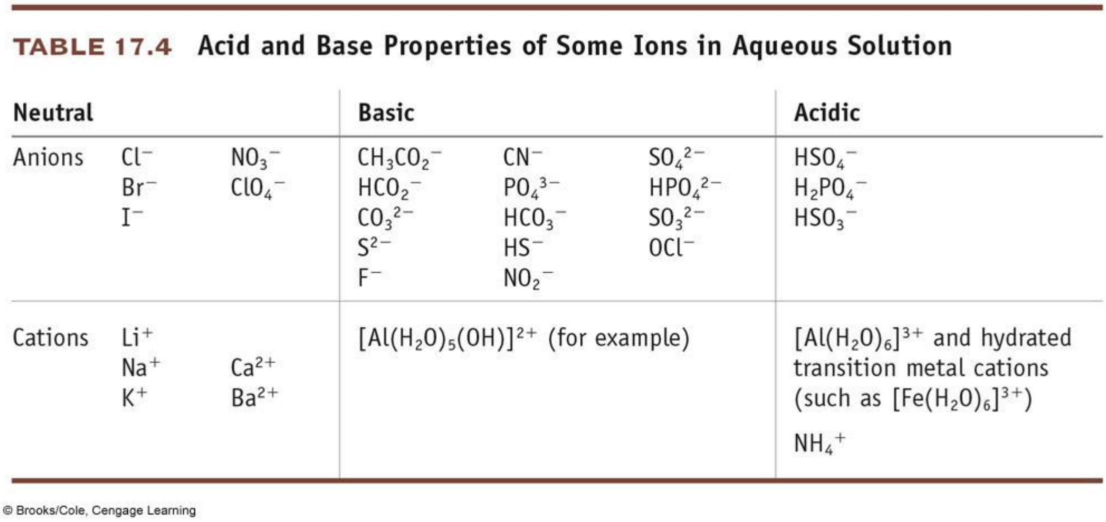


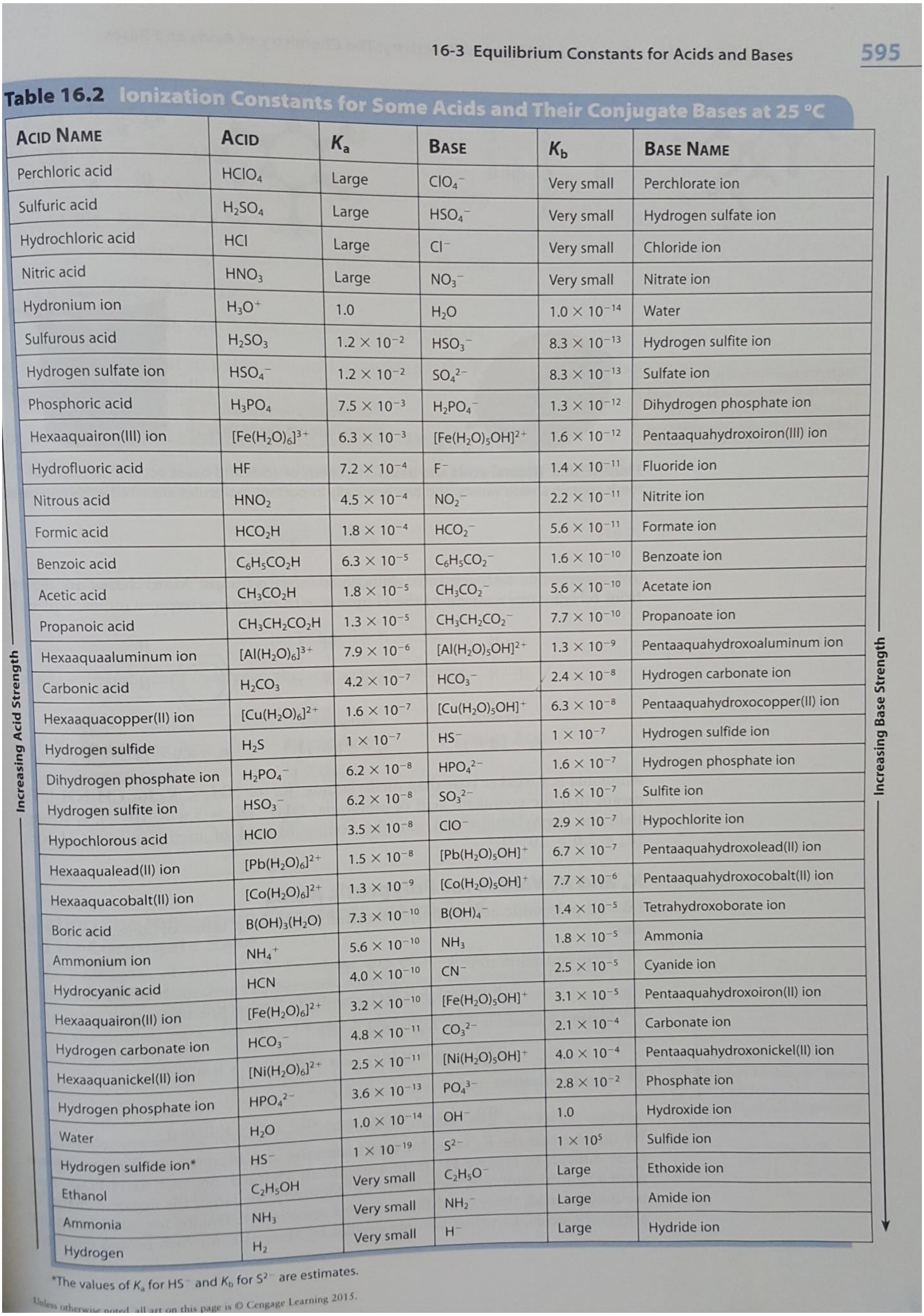
TABLE 17.4 Acid and Base Properties of Some Ions in Aqueous Solution

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 $[Fe(H_2O)_6]^{3+}$)
	Na^+	Ca^{2+}				
	K^+	Ba^{2+}				
						NH_4^+

© Brooks/Cole, Cengage Learning

TABEL 5: Ionisasiekonstantes vir sommige sure en hul gekonjugeerde basisse by 25 ⁰C.

TABLE 5: Ionization constants for some acids and their conjugated bases at 25 ⁰C.



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
Hexaaquaaluminum 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

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

Unless otherwise noted, all art on this page is © Cengage Learning 2015.