UNIVERSITY
OF SKÖVDE

School of

WRITTEN EXAMINATION

Course Basic Chemistry

Examination Supervised Written examination I (inorganic chemistry)

Course code Ke117G | Credits for written examination 5

Date 20231024 | Examination time 8.15-12.30

Examination responsible Patric Nilsson/Magnus Fagerlind

Teachers concerned

Aid at the exam/appendices Calculator

Other All questions should be answered in the exam sheet. No additional sheets are allowed.

Additional sheets will NOT be considered

Instructions

- ☐ Take a new sheet of paper for each teacher.
- ☐ Take a new sheet of paper when starting a new question.
- ☐ Write only on one side of the paper.
- ☒ Write your name and personal ID No. on all pages you hand in.
- ☒ Use page numbering.
- ☒ Don´t use a red pen.
- ☒ Mark answered questions with a cross on the cover sheet.

Grade points: To pass the exam, all learning objectives require the grade E or gigher. To pass a learning objective, 50% correct answers are required.

F< 35 <= E < 42 <= D < 49 <= C < 56 <= B < 63 <= A

Examination results should be made public within 18 working days

Good luck!

Total number of pages

Supervised written examination I (Basic Chemistry, inorganic chemistry)

Course code: KE117G

Important information regarding the exam:

The supervised written exam examines three learning objectives in total

- describe the structure of atoms, molecules and how chemical bonds are formed, and use this knowledge to name and explain the properties and structures of inorganic chemical substances (20p in total)

- use thermodynamic principles and laws to explain the mechanisms of chemical reactions and chemical equilibrium (20p in total)

- perform stoichiometric calculations, balance chemical reactions (and use these skills in the laboratory) (30p in total)

To pass the supervised written exam, all learning objectives require the grade E or higher. To pass a learning objective, at least 50 % correct answers are required.

Important things to keep in mind while writing the exam: The teacher who corrects the exam is not a mind-reader. This means that you need to show every step in your calculations otherwise it is very difficult or even impossible to follow your line of thinking. In the end, this will make a huge difference in the number of points you get on a question if you, by chance, make a simple mistake. It is strongly recommended that you make a flow-chart with all steps required to solve a question before you jump into your calculations.

All answers and calculations should be given in this exam sheet. No additional or extra sheets are allowed. Answers given on an extra sheet will not be considered.

Most importantly, believe in yourself. There are no surprises in this exam. We have talked about all the things over and over again.

Good luck

Patric

***Learning objective**: describe the structure of atoms, molecules and how chemical bonds are formed, and use this knowledge to name and explain the properties and structures of inorganic chemical substances (20p in total). You need 10/20p to pass the learning objective.*

1. Complete the following table:

Name of the element/ion	Symbol	Atomic Number	Number of protons	Number of electrons	Electrons lost/gained	
		20		18		1p
			26	24		1p
				46	1 e^- lost	1p
			25		3 e^- lost	1p
			8	10		1p

2. Use **VSEPR** (**V**alence **S**hell **E**lectron **P**air **R**epulsion) theory to predict the molecular shape (or geometry) for the following compounds. (**Hint**: **Derive the Lewis before you jump into any conclusions**).

   a) NOCl 1p
   b) CO_3^{2-} 1p
   c) NO_2^- 1p
   d) NH_3 1p
   e) H_2O 1p

3.	Name the following chemical compounds a) $Cu_3(PO_4)_2$ b) N_2O_5 c) $FeCl_3$ d) Cl_2O_7 e) Mn_2O_3 f) $SiCl_4$	 1p 1p 1p 1p 1p 1p
4.	Name the element that corresponds to each of the following a) $1s^2 2s^2 3p^6 3s^2 3p^6 4s^2$ b) Period 3 element with the second largest atomic size c) [Xe] $6s^2$ d) Group 7A element with the highest ionization energy.	 1p 1p 1p 1p
***Learning objective**: use thermodynamic principles and laws to explain the mechanisms of chemical reactions and chemical equilibrium. 50% correct answer are required to pass the learning objective. You need 10/20p to pass the learning objective*		
5.	CH_4 undergoes combustion (burns in oxygen) and two products are formed. a) Write the balanced chemical reaction b) How many kilojoules are released when 3.50 grams of CH_4 undergoes combustion? (ΔH = - 802 kJ)	 1p 3p

	c) How much Oxygen, in grams, is needed to produce 10 000 kilojoules (assuming there is an excess of CH_4).	3p
6.	Indicate how each of the following will affect the equilibrium concentration of NH_3 in the following reaction $2NH_3 + 46\ kJ \rightleftarrows N_2(g) + 3H_{2\,(g)}$	
	a) adding more H_2	0.5p
	b) increasing the temperature of the reaction	0.5p
	c) increasing the volume of the container	0.5p
	d) decreasing the volume of the container	0.5p
	e) adding a catalyst	0.5p
7.	1 .00 mol sample of NOCl (Nitrosyl Chloride) was placed in a 2.00 L reactor and heated to 227° C until the system reached equilibrium. When NOCl is heated, nitrogen oxide and chlorine gas are formed. The contents of the reactor were then analysed and found to contain 0.056 moles of Cl_2	
	a) Write the balanced chemical reaction	1p

	b) Calculate the equilibrium concentrations of NOCl, NO, and Cl_2	3p
	c) Calculate K at this temperature	1p
8.	Balance the following redox-reaction in acidic solution $Cr_2O_7^{2-}(aq) + HNO_2(aq) \longrightarrow Cr^{3+}(aq) + NO_3^-(aq)$	3p

9.	Predict the products and write a balanced equation for each of the following: a) Single replacement: $Zn\,(s) + HCl\,(aq) \longrightarrow$ b) Decomposition: $BaCO_3(s) \longrightarrow$ c) Double replacement $NiCl_2(aq) + NaOH\,(aq) \longrightarrow$ d) Combination: $Al(s) + F_2(g) \longrightarrow$ e) Combustion $C_2H_4(g) + O_2(g) \longrightarrow$	0.5p 0.5p 0.5p 0.5p 0.5p
Learning objective: perform stoichiometric calculations, balance chemical reactions (and use these skills in the laboratory). 50% correct answers are required to pass the learning objective. You need 15/30p to pass the learning objective.		
10.	Nickel (II) chloride reacts with Sodium hydroxide to form Nickel (II) hydroxide and Sodium chloride. a) Write the balanced chemical reaction	1p

b) How many millilitres of a 0.200 M NaOH solution are needed to react with 18.0 mL of a 0.500 M $NiCL_2$ solution? 2p

c) How many grams of $Ni(OH)_2$, are produced from the reaction of a 35 mL of a 1.75 M NaOH solution and excess $NiCl_2$? 2p

11. Some of the isotopes of silicon are listed in the following table

Isotope	% Natural abundance	Atomic mass	Half-life	Radiation
$^{27}_{14}Si$		26.987	4.9 s	Positron
$^{28}_{14}Si$	92.23	27.977	Stable	None
$^{29}_{14}Si$	4.683	28.976	Stable	None
$^{30}_{14}Si$	3.087	29.974	Stable	None
$^{31}_{14}Si$		30.975	2.6 h	Beta

a) In the following table, indicate the number of protons, neutrons, and electrons for each isotope 1p

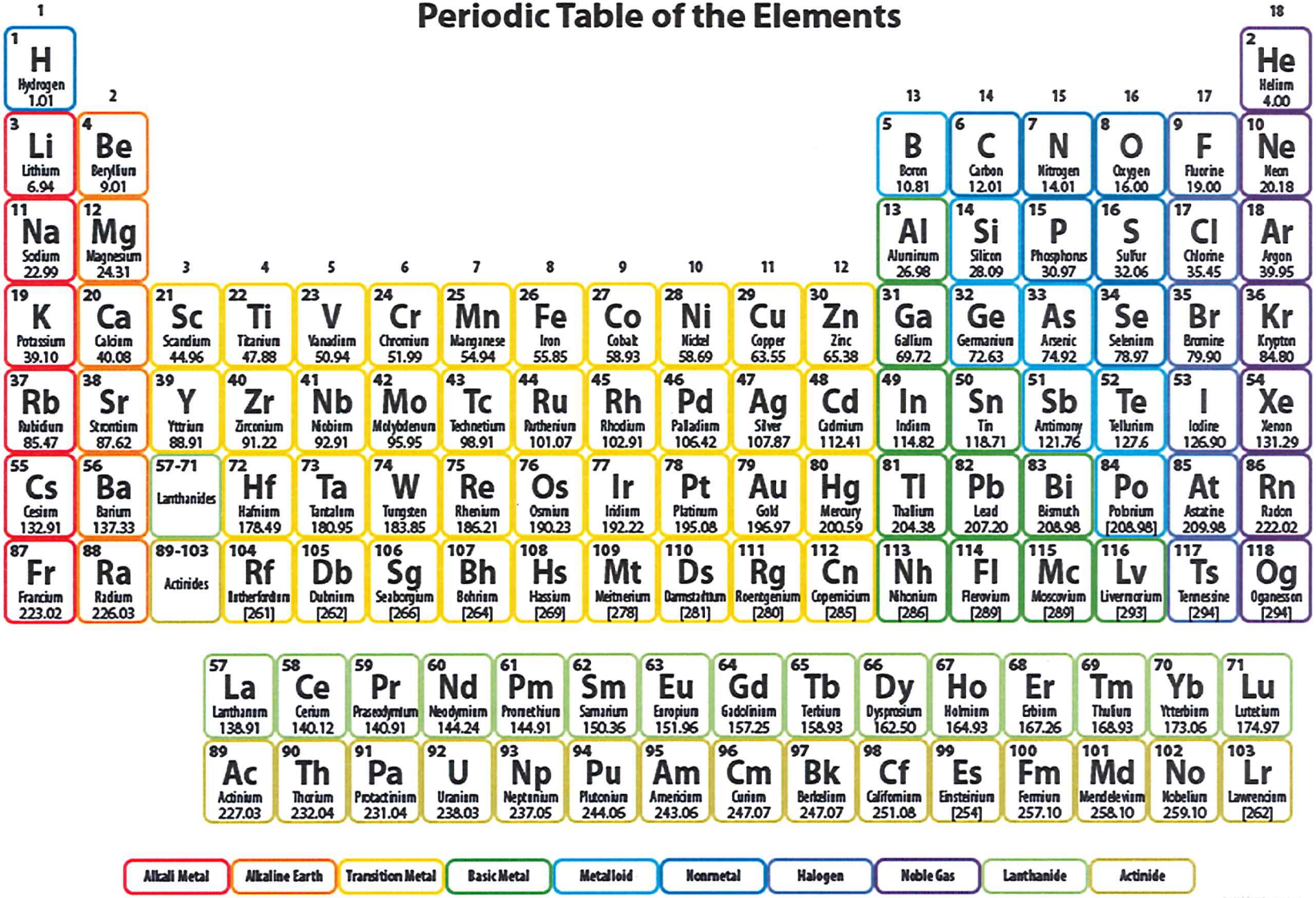
Isotope	Number of protons	Number of neutrons	Number of electrons
$^{27}_{14}Si$			
$^{28}_{14}Si$			
$^{29}_{14}Si$			
$^{30}_{14}Si$			
$^{31}_{14}Si$			

	b) What is the electron configuration of silicon?	1p
	c) Calculate the atomic mass for silicon using the weighted average mass method	2p
	d) Write the balanced nuclear equations for the positron emission of Si-27 and the beta decay of Si-31	2p
	e) Draw the Lewis structure and predict the shape of $SiCl_4$	2p
	f) How many hours are needed for a sample of Si-31 with an activity of 16μCi to decay to 2μCi?	2p

12.	Consider the following acids and their dissociation constants $H_2SO_3(aq) + H_2O(l) \rightleftarrows H_3O^+(aq) + HSO_3^-(a), K_a = 1.2x10^{-2}$ $HS^-(aq) + H_2O(l) \rightleftarrows H_3O^+(aq) + S^{2-}(aq), K_a = 1.3x10^{-19}$ a) Which is the stronger acid, H_2SO_3 or HS^-? b) What is the conjugate base of H_2SO_3? c) Which acid has the weaker conjugate base? d) Which acid has the stronger conjugate base? e) Which acid produces more ions?	0.5p 0.5p 0.5p 0.5p 0.5p
13.	Consider the buffer system of hydrofluoric acid, HF, and its salt NaF $HF(aq) + H_2O(l) \rightleftarrows H_3O^+(aq) + F^-(aq)$ a) The purpose of this buffer system is to: 1. Maintain [HF] 2. Maintain [F^-] 3. Maintain pH b) The salt of the weak acid is needed to: 1. Provide the conjugate base 2. Neutralize added H_3O^+ 3. Provide the conjugate acid c) If OH^- is added, it is neutralized by: 1. The salt 2. H_2O 3. H_3O^+ d) When H_3O^+ is added, the equilibrium shifts in direction of the: 1. reactants 2. products 3. does not change	1p 1p 1p 1p
14.	Nitrogen dioxide reacts with water to produce oxygen and ammonia (NH_3). A 5.00 liters sample of water reacts at a temperature of 375 °C and a pressure of 725 mmHg. a) Write the balanced chemical reaction b) How many grams of NH_3 can be produced?	1p 3p

15.	Determine the final volume, in millilitres, of each of the following: a) a 1.5 M HCl solution prepared from 20 mL of a 6.00 M HCl solution?	1.5p
	b) A 0.500 M H_3PO_4 solution prepared from 50mL of a 6.00 M H_3PO_4 solution?	1.5p
	c) A 5.0% (m/v) glucose solution prepared from 75 mL of a 12% (m/v) glucose solution	1.5p

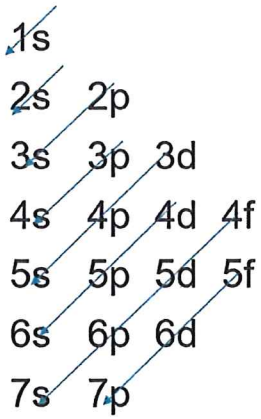
Periodic Table of the Elements



Appendix B. Formulas

Gas laws:
Boyle´s law: $P_1V_1 = P_2V_2$
Charles´s law: $\frac{V_1}{T_1} = \frac{V_2}{T_2}$
Gay-Lussac´s law: $\frac{P_1}{T_1} = \frac{P_2}{T_2}$
Avogadro´s law: $\frac{V_1}{n_1} = \frac{V_2}{n_2}$
Combined gas law: $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$
Ideal gas law: $PV = nRT$ P = Pressure (in mmHg or atm) V = Volume (in Liters) n = moles R = 62.4 L x mm Hg/(mol x K) or 0.0821 L x atm/(mole x K)
Other formulas:
n (moles) = C (Concentration) x V (Volume); m (mass in grams) = n (moles) x M (Molar mass) $C_1V_1 = C_2V_2$
$[H_3O^+] = 10^{-pH}; pH = -log_{10}[H_3O^+]; pK_a = -log_{10}[K_a]$ $[OH^-] = 10^{-pOH}; pOH = -log_{10}[OH^-]; pK_b = -log_{10}[K_b]$ $K_w = [H_3O^+]x[OH^-] = 1x10^{-14}$ pOH + pH = 14
Henderson-Hasselbalch equation $pH = pK_a + log_{10}\frac{[A^-]}{[HA]}$
$\Delta G = Gibbs\ free\ energy = \Delta H - T\Delta S$
$K_a = \frac{[H_3O^+][CHO_2^-]}{HCHO_2}$ for the following reaction $HCHO_2 + H_2O \rightleftarrows H_3O^+ + CHO_2^-$
An equation of the form $ax^2 + bx + c = 0$ can be rearranged to solve for x $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$ Keep in mind that the concentration (x) can only assume positive values

Appendix C. The orbitals in an atom fill in order of increasing energy beginning with 1s



Appendix D. Name and formulas of some common polyatomic ions

Formula of ion	Name of ion
OH^-	Hydroxide
NH_4^+	Ammonium
NO_3^-	Nitrate
NO_2^-	Nitrite
ClO_4^-	Perchlorate
ClO_3^-	Chlorate
ClO_2^-	Chlorite
$HClO_2^-$	Hypochlorite
CO_3^{2-}	Carbonate
HCO_3^-	Hydrogen carbonate
CN^-	Cyanide
$C_2H_3O_2^-$	Acetate
SO_4^{2-}	Sulphate
HSO_4^-	Hydrogen sulphate
SO_3^{2-}	Sulphite
HSO_3^-	Hydrogen sulphite
PO_4^{3-}	Phosphate
HPO_4^{2-}	Hydrogen phosphate
$H_2PO_4^-$	Dihydrogen phosphate
PO_3^{3-}	Phosphite