UNIVERSITY
OF SKÖVDE

School of Bioscience

WRITTEN EXAMINATION

Course Basic Chemistry

Examination Supervised Written Examination I

Course code Ke117G | Credits for written examination 5

Date 20231208 | Examination time 8.15-12.30

Examination responsible Patric Nilsson/Magnus Fagerlind

Teachers concerned Patric Nilsson

Aid at the exam/appendices: any calculator

Other All answers MUST be given in the exam sheet. Answers given on extra 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: F<35<= E <42 <= D < 49 <= C < 56 <= B < 63 <= 70 A

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

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.

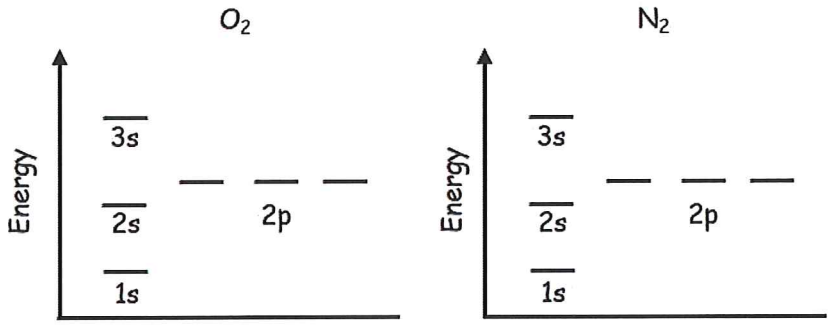
All answers and calculations should be given in this exam sheet. No additional or extra sheets are allowed. Answers given on an extra sheet will not be considered.

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.	a) In the figure below, complete the electron configuration for O_2 and N_2 using Hund´s rule and the Aufbau principle  	2p
	b) explain Hund´s rule briefly	2p
	c) explain the Aufbau principle	2p
	d) Pauli´s exclusion principle	2p
	e) Based on your figure in 1a), explain the difference in ionization energy between O_2 and N_2	2p

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) CH_4 b) NO_3^- c) NH_4^+ d) H_2O e) CH_2O	 1p 1p 1p 1p 1p
3.	Name the following chemical compounds a) $Cu_3(PO_4)$ b) $FeCl_2$ c) IF_7 d) MnO e) P_4S_9	 1p 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*		
4.	Nitrogen gas reacts with hydrogen gas to form ammonia. ΔH for the reaction is -92.6 kJ a) Write the balanced chemical reaction b) How many grams of H_2 are need to make -155 kJ	1p 3p
5.	Methanol, CH_3OH, is finding use as a fuel additive. Describe the effect of each of the following changes on the equilibrium mixture $$2CH_3OH + +3O_2 \rightleftarrows 2CO_2(g) + 4H_2O + 1450\ kJ$$ a) adding more CO_2 b) adding more O_2 c) increasing the volume of the container d) Increasing the temperature e) adding a catalyst	 0.5p 0.5p 0.5p 0.5p 0.5p

6.	Consider the following reaction $$2HI(g) \rightleftarrows H_2(g) + I_2(g)$$ If we start with 0.500 mol of HI in a 5L flask, calculate the equilibrium concentrations of each substances. K_c = 0.016	3p
7.	Balance the following redox-reaction in basic solution $$Zn + NO_3^- \longrightarrow Zn^{2+} + NO_2$$	4p

8.	Predict the products and write a balanced equation for each of the following: a) Single replacement: $Na\ (s) + HCl\ (aq) \longrightarrow$ b) Decomposition: $NaCl \longrightarrow$ c) Double replacement $KNO_3(aq) + AlCl_3\ (aq) \longrightarrow$ d) Combination: $Ca(s) + Br_2(g) \longrightarrow$ e) Combustion $C_2H_4(g) + O_2(g) \longrightarrow$	0.5p 0.5p 0.5p 0.5p 0.5p
9.	Gibbs free energy is given by the following reaction $\Delta G = \Delta H - T\Delta S$ a) Under which circumstances does a chemical reaction occur Spontaneously? b) Explain ΔG	0.8p 0.8p

	c) Explain ΔH	0.8p
	d) Explain T	0.8p
	e) Explain ΔS	0.8p
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.		
1o.	Acetylene (C_2H_2) burns according to the following reaction: $C_2H_2(g) + O_2(g) \longrightarrow CO_2(g) + H_2O(g)$ a) Balance the reaction	2p
	b) What is the theoretical yield, in grams, of CO_2, if 22.0 g of C_2H_2 completely reacts	2p

	c) If the actual yield in part b) is 64.0 g of CO_2, what is the percent yield of Co2 for the reaction?	2p
11.	Glucose, $C_6H_{12}O_6$, is metabolized in living systems according to the following reaction $C_6H_{12}O_6(s) + O_2(g) \rightarrow CO_2(g) + H_2O(l)$ a) Balance the reaction	2p
	b) How many grams of water can be produced from the reaction of 18.0 of glucose and 7.5 L of O2 at 1.00 atm and 37°C	4p

12.	Consider the following acids and their dissociation constants $HPO_4^{2-}(aq) + H_2O(l) \rightleftarrows H_3O^+(aq) + PO_4^-(a), K_a = 2.2x10^{-13}$ $HCHO_2\ (aq) + H_2O(l) \rightleftarrows H_3O^+(aq) + HCO_2^-(aq), K_a = 1.8x10^{-4}$ a) Which is the stronger acid, HPO_4^{2-} or $HCHO_2$? b) What is the conjugate base of HPO_4^{2-} c) Which acid has the weaker conjugate base? d) Which acid has the stronger conjugate base? e) Which acid produces more ions?	1p 1p 1p 1p 1p
13.	Consider the buffer system of nitrous acid, HNO_2, and its salt $NaNO_2$ $HNO_2(aq) + H_2O(l) \rightleftarrows H_3O^+(aq) + NO_2^-(aq)$ a) The purpose of this buffer system is to: 1. Maintain [HNO_2] 2. Maintain [NO_2^-] 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 NO_2^- is added, the equilibrium shifts in direction of the: 1. reactants 2. products 3. does not change	1p 1p 1p 1p
14.	A solution of 0.204 M NaOH is used to titrate 50 mL of a 0.0224 M H3PO4 solution a) write the balanced chemical reaction	2p

	b) What volume in mL of the NaOH is required?	3p
15.	Cesium-137, used in cancer treatment, has a half-life of 30 years a) Write the balanced nuclear reaction for the beta decay of cesium-137	2p
	b) How many milligrams of a 16mg sample of cesium-137 remain after 90 years	1p
	c) How many years are required for 28 mg of cesium-137 to decay to 3.5 mg of cesium-137?	1p

Appendix B. The Periodic Table of Elements

Periodic Table of the Elements

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H Hydrogen 1.01																	2 He Helium 4.00
3 Li Lithium 6.94	4 Be Beryllium 9.01											5 B Boron 10.81	6 C Carbon 12.01	7 N Nitrogen 14.01	8 O Oxygen 16.00	9 F Fluorine 19.00	10 Ne Neon 20.18
11 Na Sodium 22.99	12 Mg Magnesium 24.31											13 Al Aluminum 26.98	14 Si Silicon 28.09	15 P Phosphorus 30.97	16 S Sulfur 32.06	17 Cl Chlorine 35.45	18 Ar Argon 39.95
19 K Potassium 39.10	20 Ca Calcium 40.08	21 Sc Scandium 44.96	22 Ti Titanium 47.88	23 V Vanadium 50.94	24 Cr Chromium 51.99	25 Mn Manganese 54.94	26 Fe Iron 55.85	27 Co Cobalt 58.93	28 Ni Nickel 58.69	29 Cu Copper 63.55	30 Zn Zinc 65.38	31 Ga Gallium 69.72	32 Ge Germanium 72.63	33 As Arsenic 74.92	34 Se Selenium 78.97	35 Br Bromine 79.90	36 Kr Krypton 84.80
37 Rb Rubidium 85.47	38 Sr Strontium 87.62	39 Y Yttrium 88.91	40 Zr Zirconium 91.22	41 Nb Niobium 92.91	42 Mo Molybdenum 95.95	43 Tc Technetium 98.91	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.91	46 Pd Palladium 106.42	47 Ag Silver 107.87	48 Cd Cadmium 112.41	49 In Indium 114.82	50 Sn Tin 118.71	51 Sb Antimony 121.76	52 Te Tellurium 127.6	53 I Iodine 126.90	54 Xe Xenon 131.29
55 Cs Cesium 132.91	56 Ba Barium 137.33	57-71 Lanthanides	72 Hf Hafnium 178.49	73 Ta Tantalum 180.95	74 W Tungsten 183.85	75 Re Rhenium 186.21	76 Os Osmium 190.23	77 Ir Iridium 192.22	78 Pt Platinum 195.08	79 Au Gold 196.97	80 Hg Mercury 200.59	81 Tl Thallium 204.38	82 Pb Lead 207.20	83 Bi Bismuth 208.98	84 Po Polonium [208.98]	85 At Astatine 209.98	86 Rn Radon 222.02
87 Fr Francium 223.02	88 Ra Radium 226.03	89-103 Actinides	104 Rf Rutherfordium [261]	105 Db Dubnium [262]	106 Sg Seaborgium [266]	107 Bh Bohrium [264]	108 Hs Hassium [269]	109 Mt Meitnerium [278]	110 Ds Darmstadtium [281]	111 Rg Roentgenium [280]	112 Cn Copernicium [285]	113 Nh Nihonium [286]	114 Fl Flerovium [289]	115 Mc Moscovium [289]	116 Lv Livermorium [293]	117 Ts Tennessine [294]	118 Og Oganesson [294]

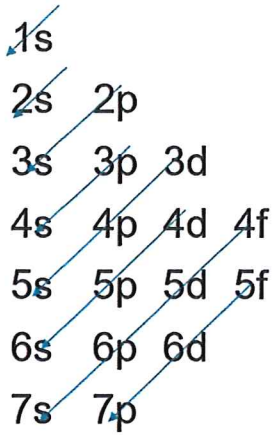
57 La Lanthanum 138.91	58 Ce Cerium 140.12	59 Pr Praseodymium 140.91	60 Nd Neodymium 144.24	61 Pm Promethium 144.91	62 Sm Samarium 150.36	63 Eu Europium 151.96	64 Gd Gadolinium 157.25	65 Tb Terbium 158.93	66 Dy Dysprosium 162.50	67 Ho Holmium 164.93	68 Er Erbium 167.26	69 Tm Thulium 168.93	70 Yb Ytterbium 173.06	71 Lu Lutetium 174.97
89 Ac Actinium 227.03	90 Th Thorium 232.04	91 Pa Protactinium 231.04	92 U Uranium 238.03	93 Np Neptunium 237.05	94 Pu Plutonium 244.06	95 Am Americium 243.06	96 Cm Curium 247.07	97 Bk Berkelium 247.07	98 Cf Californium 251.08	99 Es Einsteinium [254]	100 Fm Fermium 257.10	101 Md Mendelevium 258.10	102 No Nobelium 259.10	103 Lr Lawrencium [262]

Alkali Metal | Alkaline Earth | Transition Metal | Basic Metal | Metalloid | Nonmetal | Halogen | Noble Gas | Lanthanide | Actinide

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