UNIVERSITY
OF SKÖVDE

School of Bioscience

WRITTEN EXAMINATION

Course Basic Chemistry (SWE: Grundläggande kemi)

Examination: Supervised written examination I

Course code Ke117G | Credits for written examination 5

Date 2024-12-12 | Examination time 14.15-18.30

Examination responsible Patric Nilsson (course coordinator)/Magnus Fagerlind (examiner)

Teachers concerned Patric Nilsson/Magnus Fagerlind

Aid at the exam/appendices: calculator. The students can use their own calculator or borrow one from the university

Other: All answers MUST be given in the exam sheet. Answers given on additional/extra sheets will NOT be considered. Take your time to go through the exam. Do the demanding tasks/question first, while your brain or mind is fresh. Bonus points earned during lectures and on quizzes will be added to each learning objective.

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 higher. To pass a learning objective, 50% correct answers are required.

F < 35 <= E < 42 <= D < 49 <= C < 56 <= B < 63 <= 70 A

Examination results should be made public within 18 working days

Good luck! Total number of pages

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 structure of inorganic chemical substances. You need 10/20p to pass the learning objective

1 Complete the following table for atoms and ions — 4

Atom or Ion	Number of protons	Number of electrons	Electrons lost/gained
	30		2 e^- lost
	36	36	
		46	4 e^- lost
	20	18	

2 Classify each of the following as ionic or molecular, and name each:

a) LiF — 1

b) $SiBr_4$ — 1

c) $Fe_3(PO_4)_2$ — 1

d) GeH_4 — 1

3 Consider three elements with the following abbreviated electron configuration:
$X=[Ar]4s^23d^5$
$Y=[Ar]4s^23d^{10}4p^1$
$Z=[Ne]3s^23p^2$

a) Identify each element as a metal, a non-metal, or a metalloid — 1

b) Which element has the largest atomic size? — 1

c) Which elements have similar properties? — 1

d) Which element has the highest ionization energy? — 1

e) Which element has the smallest atomic size? — 1

f) Identify which elements X, Y and Z are? — 1

4 Use VSEPR theory to predict the molecular shape (geometry) for the following compounds (Hint: derive the Lewis structure before you jump into any conclusions)

a) NH_3 — 1.5

b) NH_4^+ — 1.5

c) NO_3^- — 1.5

d) NO_2^- — 1.5

Learning objective: use thermodynamic principles and laws to explain the mechanisms of chemical reactions and chemical equilibrium. You need 10/20p to pass the learning objective.		
5	Balance each of the following chemical reactions, and identify the type of reaction: a) $Fe(OH)_3(s) \rightarrow Fe_2O_3(s) + H_2O(g)$ b) $CuS(s) + HCl\ (aq) \rightarrow CuCl_2(aq) + H_2S(g)$	2 2
6	Balance the following redox reaction in acidic solution $Br_2 \rightarrow BrO_3^- + Br^-$	3
7	A 5.00 L flask is, initially, filled with 0.500 mole of HI gas. It decomposes to iodine and fluorine gas. The equilibrium constant for the reaction is 0.016. a) Write and balance the reaction	1

	b) What are the equilibrium concentrations of I_2 (g), H_2 (g), and HI (g)	4
	If the system is at equilibrium, how would it respond to each of the following	
	c) Adding more I_2	0.5
	d) Adding a catalyst	0.5
	e) Adding more HI	0.5
	f) Increasing the volume of the container	0.5
8	Methanol reacts with oxygen gas. As a result, water and carbon dioxide are formed. Also, energy is released (ΔH= -726 kJ).	
	a) Write and balance the reaction	1
	b) What type of reaction is?	0.5
	c) Is the reaction endothermic or exothermic?	0.5

	d) How much heat, in KJ, is produced when 75 grams of methanol reacts	3
Learning objective: perform stoichiometric calculations, balance chemical reactions (and use these skills in the laboratory). You need 15/30p to pass the learning objective.		
9	HCl reacts with magnesium (s) to form hydrogen gas and magnesium a) Write and balance the reaction	1
	b) How many milliliters of a 6.00 M HCl solution are required to react with 15.0 grams of Magnesium	4
10	HCl reacts with aluminium to produce hydrogen gas and aluminium chloride a) Write the balanced chemical reaction	1

	b) If 12.8 grams of aluminium reacts with HCl, how many litres of H_2 would be formed at 715 mmHg and 19° C?	4
11	Calculate the final concentration of each of the following: a) 2.0 L of a 6.00 M HCl solution is added to water so that the final volume is 6.0 L.	2
	b) Water is added to 0.50 L of a 12.0 M NaOH solution to make 3.0 L of a diluted NaOH solution.	2
	c) A 10.0 mL sample of a 25% (m/v) KOH solution is added to water to give a final volume of 100 mL	2
12	What is the pH of a buffer prepared with 0.70 M ammonia (NH_3) and 0.90 M ammonium chloride (NH_4Cl), if the pK_a 9.248?	3
13	Determine each of the following for a 0.10 M HBr solution: a) [OH-]	1.5

	b) pH	1.5
	c) the balanced equation for the reaction with LiOH	2
	d) millilitres of HBr solution required to neutralize 36.0 mL of a 0.25 M LiOH solution	3
14	Xenon-133 is used to test lung function; it decays by emitting a beta particle a) Write an equation for the beta decay of Xenon-133.	1.5
	b) If the half-life of Xenon-133 is 5.2 hours, how much of a 20.0 mCi sample is still active after 15.6 hours?	1.5

Equations and tables

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Constants

$N_A = 6{,}022 \cdot 10^{23}$ /mol

R = 62.4 L x mm Hg/ (mol x K) or 0.0821 L x atm/ (mole x K)

$1\ u = 1{,}661 \cdot 10^{-27}$ kg

0° C = 273.15 K

Equations

M = m/n (Molar Mass = Mass in gram/moles)

c = n/V (concentration =moles/Volume (in litres))

$m = c \cdot V \cdot M$

$c_1 \cdot V_1 = c_2 \cdot V_2$

$q = c \cdot m \cdot \Delta T$

$\Delta G = \Delta H - T \cdot \Delta S$ (Gibbs free energy)

$p \cdot V = n \cdot R \cdot T$ *(Ideal Gas Law)*

Boyle´s law: $P_1 V_1 = P_2 V_2$

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: $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$

$E = e^o_{plus\ pole} - e^o_{minus\ pole}$

$A = \varepsilon \cdot c \cdot l$

$$\mathrm{pH} = pK_a + log\frac{c_{(\mathrm{base})}}{c_{(\mathrm{acid})}}$$

$$\mathrm{H}^+ = K_a \cdot \frac{c_{(\mathrm{syra})}}{c_{(\mathrm{bas})}}$$

$[H_3O^+] = 10^{-pH}; pH = -log_{10}[H_3O^+]; pK_a = -log_{10}[K_a]$

$[OH^-] = 10^{-pOH}; pOH = -log_{10}[OH^-]; pK_b = -log_{10}[K_b]$

$K_w = [H_3O^+]x[OH^-] = 1x10^{-14}$

pOH + pH = 14

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.

$$K_a = \frac{[H_3O^+][CHO_2^-]}{HCHO_2}$$

for the following reaction

$$HCHO_2 + H_2O \rightleftarrows H_3O^+ + CHO_2^-$$

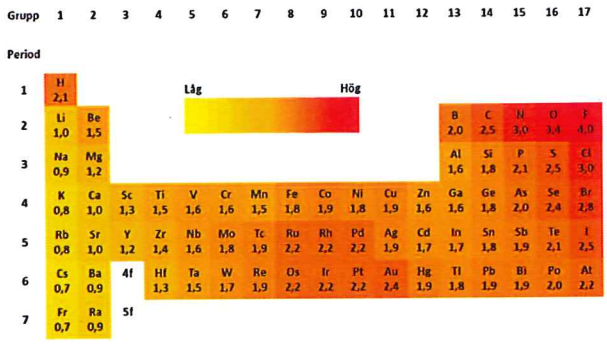
Solubility rules

Löslig om saltet innehåller:		Olöslig om saltet innehåller:
NH_4^+, Li^+, Na^+, K^+ NO_3^-, $C_2H_3O_2^-$ (acetat)	men är lösligt med	CO_3^{2-}, S^{2-}, PO_4^{3-}, OH^-
Cl^-, Br^-, I^-	men är inte lösligt med	Ag^+, Pb^{2+}, Hg_2^{2+}
SO_4^{2-}	men är inte lösligt med	Ba^{2+}, Pb^{2+}, Ca^{2+}, Sr^{2+}

Normal potentials

Oxform + ne⁻ ⇄	Redform	e° (V)
$Li^+(aq) + e^-$	$Li(s)$	-3,04
$K^+(aq) + e^-$	$K(s)$	-2,92
$Ca^{2+}(aq) + 2e^-$	$Ca(s)$	-2,76
$Na^+(aq) + e^-$	$Na(s)$	-2,71
$Mg^{2+}(aq) + 2e^-$	$Mg(s)$	-2,38
$Al^{3+}(aq) + 3e^-$	$Al(s)$	-1,66
$2H_2O(l) + 2e^-$	$H_2(g) + 2OH^-(aq)$	-0,83
$Zn^{2+}(aq) + 2e^-$	$Zn(s)$	-0,76
$Cr^{3+}(aq) + 3e^-$	$Cr(s)$	-0,74
$Fe^{2+}(aq) + 2e^-$	$Fe(s)$	-0,41
$Cd^{2+}(aq) + 2e^-$	$Cd(s)$	-0,40
$PbSO_4(s) + H^+ + 2e^-$	$Pb(s) + HSO_4^-$	-0,36
$Ni^{2+}(aq) + 2e^-$	$Ni(s)$	-0,23
$Sn^{2+}(aq) + 2e^-$	$Sn(s)$	-0,14
$Pb^{2+}(aq) + 2e^-$	$Pb(s)$	-0,13
$Fe^{3+}(aq) + 3e^-$	$Fe(s)$	-0,04
$2H^+(aq) + 2e^-$	$H_2(g)$	0,00
$Cu^{2+}(aq) + 2e^-$	$Cu(s)$	0,34
$O_2(g) + 4H^+ + 3e^-$	$2H_2O$	0,40
$I_2(s) + 2e^-$	$2I^-(aq)$	0,54
$Ag^+(aq) + e^-$	$Ag(s)$	0,80
$NO_3^-(aq) + 4H^+(aq) + 3e^-$	$NO(g) + 2H_2O(l)$	0,96
$Br_2(l) + 2e^-$	$2Br^-(aq)$	1,07
$O_2(g) + 4H^+(aq) + 4e^-$	$2H_2O(l)$	1,23
$Cl_2(g) + 2e^-$	$2Cl^-(aq)$	1,36
$MnO_4^-(aq) + 8H^+(aq) + 5e^-$	$Mn^{2+}(aq) + 4H_2O(l)$	1,49
$Au^{3+}(aq) + 3e^-$	$Au(s)$	1,50
$O_3(g) + 2H^+(aq) + 2e^-$	$O_2(g) + H_2O(l)$	2,07
$F_2(g) + 2e^-$	$2F^-(aq)$	2,87

Electronegativity values



Electronegativity–bonds

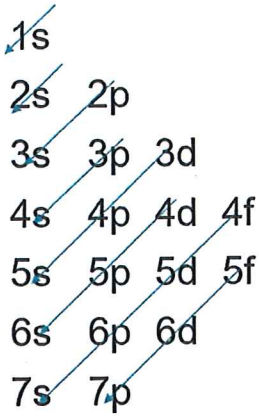
Δ > 1,8	Ionic
Δ = 1,8–0,5	Polar covalent bond
Δ = 0,4–0,0	Covalent bond

Element	Symbol	#	Atomic mass (u)
Actinium	Ac	89	227,0278
Aluminium	Al	13	26,98153
Americium	Am	95	243,0614
Antimony	Sb	51	121,75
Argon	Ar	18	39,948
Arsenic	As	33	74,92159
Astatine	At	85	209,9871
Barium	Ba	56	137,327
Berkelium	Bk	97	247,0703
Beryllium	Be	4	9,012182
Bly	Pb	82	207,2
Bohrium	Bh	107	262,1229
Boron	B	5	10,811
Bromine	Br	35	79,904
Californium	Cf	98	251,0796
Cerium	Ce	58	140,115
Cesium	Cs	55	132,9054
Copernicum	Cn	112	277
Curium	Cm	96	247,0703
Darmstadtium	Ds	110	269
Dubnium	Db	105	262,1138
Dysprosium	Dy	66	162,5
Einsteinium	Es	99	252,0829
Erbium	Er	68	167,26
Europium	Eu	63	151,965
Fermium	Fm	100	257,0951
Flerovium	Fl	114	
Fluorine	F	9	18,99840
Phosphorous	P	15	30,97376
Francium	Fr	87	223,0197
Gadolinium	Gd	64	157,25
Gallium	Ga	31	69,723
Germanium	Ge	32	72,61
Gold	Au	79	196,9665
Hafnium	Hf	72	178,49
Hassium	Hs	108	265
Helium	He	2	4,002602
Holmium	Ho	67	164,9303
Indium	In	49	114,82
Iridium	Ir	77	192,22
Iodine	I	53	126,9044
Iron	Fe	26	55,847
Cadmium	Cd	48	112,411
Calcium	Ca	20	40,078
Potassium	K	19	39,0983
Silicon	Si	14	28,0855
Chlorine	Cl	17	35,4527
Kobalt	Co	27	58,9332
Carbon	C	6	12,011
Copper	Cu	29	63,546
Chromium	Cr	24	51,9961
Krypton	Kr	36	83,8
Mercury	Hg	80	200,59
Nitrogen	N	7	14,00674
Lanthanum	La	57	138,9055
Lawrencium	Lr	103	260,1053
Lithium	Li	3	6,941
Livermorium	Lv	116	
Lutetium	Lu	71	174,967
Magnesium	Mg	12	24,305
Manganese	Mn	25	54,93805
Medelevium	Md	101	258,0986
Meitnerium	Mt	109	266
Molybdenum	Mo	42	95,94
Sodium	Na	11	22,98976
Neodym	Nd	60	144,24
Neon	Ne	10	20,1797
Neptunium	Np	93	237,0482
Nickel	Ni	28	58,69
Niobium	Nb	41	92,90638
Nobelium	No	102	259,1009
Osmium	Os	76	190,2
Palladium	Pd	46	106,42
Platina	Pt	78	195,08
Plutionium	Pu	94	244,0642
Polonium	Po	84	208,9824
Praseodym	Pr	59	140,9076
Promethium	Pm	61	146,9151
Protactinium	Pa	91	231,0359
Radium	Ra	88	226,0254
Radon	Rn	86	222,0176
Rhenium	Re	75	186,207
Rhodium	Rh	45	102,9055
Rubidium	Rb	37	85,4678
Ruthenium	Ru	44	101,07
Rutherfordium	Rf	104	261,1087
Röntgenium	Rg	111	272
Samarium	Sm	62	150,36
Seaborgium	Sg	106	263,1182
Selenium	Se	34	78,96
Silver	Ag	47	107,8682
Scandium	Sc	21	44,95591
Strontium	Sr	38	87,62
Sulfur	S	16	32,066
Oxygen	O	8	15,9994
Thallium	Tl	81	204,3833
Tantalum	Ta	73	180,9479
Technetium	Tc	43	98,9063
Tellurium	Te	52	127,6
Tin	Sn	50	118,71
Terbium	Tb	65	158,9253
Titanium	Ti	22	47,88
Thorium	Th	90	232,0381
Thulium	Tm	69	168,9342
Ununoctium	Uuo	118	
Ununpentium	Uup	115	
Ununseptrium	Uus	117	
Ununtrium	Uut	113	
Uranium	U	92	238,0289
Vanadium	V	23	50,9415
Bismuth	Bi	83	208,9803
Tungsten	W	74	183,85
Hydrogen	H	1	1,00794
Xenon	Xe	54	131,29
Ytterbium	Yb	70	173,04
Yttrium	Y	39	88,90585
Zinc	Zn	30	65,39
Zirconium	Zr	40	91,224

Element	Symbol	Nr	Atomic mass (u)

Element	Symbol	Nr	Atomic mass (u)

The order in which orbitals are filled



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

Priority rules

	Group	Prefix	Suffix
High Priority	Carboxylic acid	carboxy-	-oic acid
	Ester	oxycarbonyl-	-oate
	Amide	carbamoyl-	-amide
	Aldehyde	formyl-	-al
	Ketone	oxo-	-one
	Alcohol	hydroxy-	-ol
	Thiol	mercapto-	-thiol
	Amine	amino-	-amine
	Alkene	alkenyl-	-ene
	Alkyne	alkynyl-	-yne
	Alkane*	**alkyl-**	**-ane**
	Ether	alkoxy-	-ane
Low priority	Halo	halo-	-ane
	Nitro	nitro-	-ane