UNIVERSITY OF TORONTO SCARBOROUGH

CHMB31H3
Introduction to Inorganic Chemistry

Term test 2

November 19, 2018

Candidate Form

Before you begin your examination, please fill out this form and leave it at the side of your desk along with your student I.D. Please sign at time of collection.

Room # _____ **Seat # (if assigned)** _____

Name (please print):_____

Surname Given Names

Student Number: | | | | | | | | | | |

Course: __CHMB31H3__ **Instructor's Name**: __Alen Hadzovic_____

Signature: _____

(sign only at time form is collected)

CHMB31H3 – Introduction to Inorganic Chemistry
Term test 2

November 19, 2018

Answer all questions in full.

Value of each question is indicated. Total is 79 marks.

***Aids Allowed*: Periodic Table of Elements provided at the back**

Please, read each question carefully and make sure you have indeed answered every part of each question!!!

Duration: 90 min (1.5 h)

GOOD LUCK!!

Student Name: _____

Student Number: _____

Name: _____ Student No.:_____

1. (10 marks) Provide the formulas for the following compounds

a. Sodium fluoride: _____NaF_____

b. Potassium hydrogencarbonate: __$KHCO_3$ _____

c. Strontium carbide: ____ SrC_2 _____

d. Lithium oxide: _____ Li_2O _____

e. Boron nitride: ____ BN _____

f. Germanium(II) chloride: ___ $GeCl_2$ _____

g. Silicic acid: _____ $Si(OH)_4$ _____

h. Lithium tetrahydroaluminate: ___ $LiAlH_4$ _____

i. Thallium(I) sulfate: ___ Tl_2SO_4 _____

j. Magnesium tetrafluoroborate: __ $Mg(BF_4)_2$ _____

2. (*5 marks*) Using Wade's rules predict the likely structure type for $B_{11}H_{13}^{2-}$ anion. (Only the type is required! You do not have to suggest and/or draw structure!)

Answer:

11 BH = 11 electron pairs

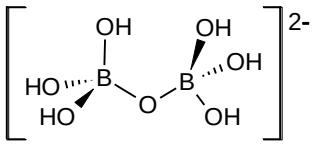
2 H = 1 electron pair

2- charge = 1 electron pair

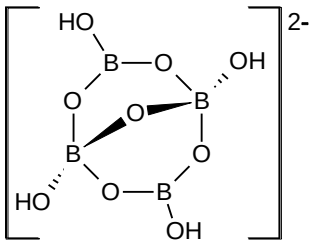
13 electron pairs = n + 2 = nido cluster

Name: _____ Student No.:_____

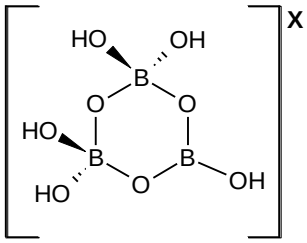
3. (*7 marks*) Consider borate anions **I**, **II** and **III** shown below.



I



II



III

a. Determine the number of Lewis acidic boron atoms for all three anions

b. Determine the charge on anion **III**. Show any calculation and/or reasoning.

Answer:

a.

No. of Lewis acidic B atoms in **I** ___ 0 ____, in **II** ____ 2 ___ and in **III** ____ 1 _____.

b.

3 × B(3+) = 9+

3 × O(2-) = 6-

5 × OH(1-) = 5-

Charge is 2-

4. (10 marks) Give balanced equations predicting the products for the following reactions:

a. Barium fluoride and boron trifluoride

b. Lithium oxide and carbon dioxide

c. Calcium and nitrogen

d. Rubidium hydroxide and beryllium hydroxide

e. Thermal decomposition of solid $CaCO_3$

Answer:

a. $BaF_2 + 2\ BF_3 = Ba(BF_4)_2$

b. $Li_2O + CO_2 = Li_2CO_3$

(more space on the next page!)

c. $3\ Ca + N_2 = Ca_3N_2$

d. $2\ RbOH + Be(OH)_2 = Rb_2[Be(OH)_4]$

e. $CaCO_3 = CaO + CO_2$

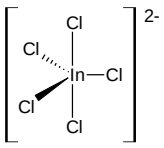
5. (5 *marks*) Indium trichloride easily reacts with two equivalents of ammonium chloride and produces a ionic solid.

a. What is the formula of the product?
b. Draw a clear structure of the anion found in the product.
c. BCl_3 does not react with two equivalents of ammonium chloride. Why not?

Answer:

a. Formula is: $[NH_4]_2[InCl_5]$

b. Structure of the anion:



c. Because…

The B atom has a smaller radius and cannot accommodate more than four Cl atoms.

6. (*4 marks*) Explain what is:

a. Temporary water hardness

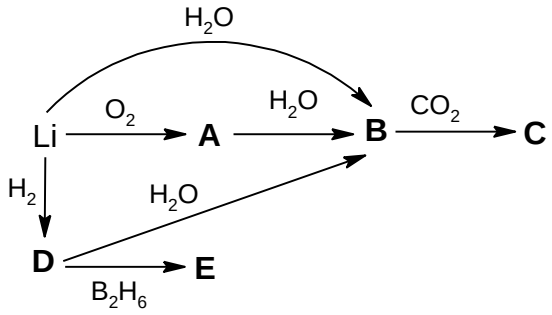
b. Permanent water hardness.

Answer:

a. Temporary water hardness is caused by dissolved Ca^{2+} and Mg^{2+} hydrogencarbonates. It is considered temporary because it can be removed simply by boiling water for a while.

b. Permanent water hardness is caused by dissolved Mg^{2+} and Ca^{2+} sulfates and chlorides. To remove this type of hardness water must be distilled or otherwise treated. It is not removed by boiling.

7. (*12 marks*) Identify lithium-containing products **A**–**E** in the following scheme and write balanced chemical equation for each reaction:



Answer:

A: Li_2O B: LiOH C: $LiHCO_3$ or Li_2CO_3 D: LiH E: $LiBH_4$

Reactions (more space on the next page!):

$4\ Li + O_2 \rightarrow 2\ Li_2O$

$Li_2O + H_2O \longrightarrow 2\ LiOH$

$LiOH + CO_2 \longrightarrow LiHCO_3$ or $2\ LiOH + CO_2 \longrightarrow Li_2CO_3 + H_2O$

$Li + H_2O \longrightarrow LiOH + ½\ H_2$

$Li + ½\ H_2 \longrightarrow LiH$

$LiH + H_2O \rightarrow LiOH + ½\ H_2$

$2\ LiH + B_2H_6 \rightarrow 2\ LiBH_4$

8. (*3 marks*) Identify the following from the given choices (circle your answer):

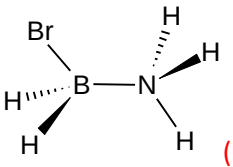
a.	The most stable oxide	SiO	GeO	**PbO**
b.	Most covalent hydride	CaH_2	MgH_2	**BeH_2**
c.	The compound sodium is isolated from	**NaCl**	$NaHCO_3$	Na_2SO_4

9. (*5 marks*) Suggest the product of a reaction between $H_2B{=}NH_2$ and HBr and explain your reasoning. Draw the product's structure.

Answer:

$H_2B{=}NH_2 + HBr \rightarrow H_2BrB{-}NH_3$

The partial charges on B (positive) and on N (negative) dictate addition of Br^- to B and H^+ to N (Alternatively: B is Lewis acidic and can react with Lewis base Br^-, N is a Lewis base and reacts with H^+ as Lewis acid)



(Note staggered conformation around B–N bond!)

10. (3 marks) Provide three examples that demonstrate the similarity between chemistry of boron and chemistry of silicon.

Answer:

1. Both B and Si form strong bonds with oxygen and fluorine

2. B_2O_3 and SiO_2 are both acidic, solid oxides with network structures

3. B and Si make weak hydroxyl acids

11. (*5 marks*)

a. A silvery metallic element has the following values of the first three ionization potentials: I_1 = 900 kJ mol^{-1}, I_2 = 1760 kJ mol^{-1} and I_3 = 14 850 kJ mol^{-1}. To which group of the periodic table this metal belongs? Explain.

b. The metal has a well-known chloride that does not conduct electricity when molten. Its hydride cannot be obtained directly from the metal and hydrogen. Identify the metal and explain your reasoning.

Answer:

a. The metal belongs to Group _ 2 _ because of the large difference between I_2 and I_3 – I_3 clearly removes a core electron

b. The metal is __ Be ___ because it creates polar covalent bonds and its hydride has formation enthalpy of about 0 kJ mol^{-1}

12. (*10 marks*) Unlike CH_4, SiH_4 rapidly reacts with water.

a. Suggest the products for the reaction between SiH_4 and H_2O.

b. Draw a mechanism for the reaction between SiH_4 and one molecule of H_2O.

c. Why is CH_4 unreactive towards water but SiH_4 is?

Answer:

a.

b.

c.

- END OF TEST -

Name: _____ Student No.:_____

																	2
																	He
																	4,0026
											5	6	7	8	9	10	
											B	C	N	O	F	Ne	
											10,811	12,01115	14,0067	15,9994	18,9984	20,183	
											13	14	15	16	17	18	
											Al	Si	P	S	Cl	Ar	
											26,9815	28,086	30,9738	32,064	35,453	39,948	
											31	32	33	34	35	36	
											Ga	Ge	As	Se	Br	Kr	
											69,72	72,59	74,922	78,96	79,909	83,8	
											49	50	51	52	53	54	
											In	Sn	Sb	Te	I	Xe	
											114,82	118,69	121,75	127,60	126,9044	131,3	
											81	82	83	84	85	86	
											Tl	Pb	Bi	Po	At	Rn	
											204,37	207,19	208,98	(210)	(210)	(222)	
											114		116		118		
											Fl		Lv		Uuo		
											(285)		(289)		(293)		

1	1																
H																	
1,00797																	
3	4																
Li	Be																
6,989	9,0122																
11	12																
Na	Mg																
22,9898	24,312																
19	20	21	22	23	24	25	26	27	28	29	30						
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn						
39,102	40,08	44,956	47,90	50,942	51,996	54,938	55,847	58,9332	58,71	63,546	65,37						
37	38	39	40	41	42	43	44	45	46	47	48						
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd						
85,47	87,62	88,905	91,22	92,906	95,94	(98)	101,07	102,905	106,4	107,87	112,40						
55	56	57	72	73	74	75	76	77	78	79	80						
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg						
132,905	137,34	138,91	178,49	180,948	183,85	186,2	190,2	192,2	195,09	196,967	200,59						
87	88	89	104	105	106	107	108	109	110	111	112						
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn						
(223)	(226)	(227)	(260)	(260)	(263)	(262)	(265)	(266)	(269)	(272)	(277)						

58	59	60	61	62	63	64	65	66	67	68	69	70	71		
Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu		
140,12	140,907	144,24	(147)	150,35	151,96	157,25	158,924	162,5	164,93	167,26	168,934	173,04	174,97		
90	91	92	93	94	95	96	97	98	99	100	101	102	103		
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr		
232,038	(231)	238,03	(237)	(244)	(243)	(247)	(247)	(249)	(254)	(253)	(256)	(254)	(257)		