CHEM-E4130: CHEMISTRY OF ELEMENTS

Exam 10.12.2020

1 H																	2 He
3 Li	4 Be											5 8	6 C	7 N	8 0	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 CI	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 1	54 Xe
55 Cs	56 Ba	57 to 71	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Ti	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89 to 103	104 Rf	105 Ha	106 Sg	107 Ns	108 Hs	109 Mt									

57	58	59	60	61	62	63	64	65	66	67	68	69	70	71
La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
89	90	91	92	93	94	95	96	97	98	99	100	101	102	103
Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

- 1. Explain the following terms (preferably with your own words):
 - a. rare earth element
 - *b.* critical raw material
 - c. critical temperature of superconductivity
 - d. disproportionation
 - e. mixed valence
 - f. photoluminescence
 - g. upconversion emission
 - *h.* metal-organic framework
 - *i.* metal complex
 - *j.* molecular layer deposition
- 2. Latimer diagrams for three imaginary elements, A, B and C, are shown below.

 $AO_{2^{+}} \xrightarrow{+1.0 \text{ V}} AO^{2_{+}} \xrightarrow{+0.3 \text{ V}} A^{3_{+}} \xrightarrow{-0.2 \text{ V}} A^{2_{+}} \xrightarrow{-1.1 \text{ V}} A$ $BO_{4^{2^{-}}} \xrightarrow{+2.1 \text{ V}} B^{3_{+}} \xrightarrow{+0.8 \text{ V}} B^{2_{+}} \xrightarrow{-0.4 \text{ V}} B$ $C^{2_{+}} \xrightarrow{+0.2 \text{ V}} C^{+} \xrightarrow{+0.6 \text{ V}} C$

- a. Draw the corresponding Frost diagrams for all the three elements.
- b. Based on the Frost diagrams, give the most stable species for each of the three elements.
- c. Based on the Frost diagrams, judge which (if any) of the species tend(s) to disproportionate.
- 3. (i) Explain based on electron configurations the following facts concerning melting points:
 - a. Alkaline earth metals have higher melting points than alkali metals.
 - b. Cd has lower melting point than transition metals.
 - *c*. Yb has lower melting point than most of the lanthanides.
 - (ii) Organize the following elements in the order of atomic radius (assuming same coordination number); most importantly, justify well your answer: Rb, Ca, Sr, Y, La, Zr, Hf.
 - (iii) Answer (<u>with short arguments</u>) to the following questions related to the oxidation states of the elements: Sc, Zr, Cu, Y, La, Eu, Gd and Tb.
 - a. Which of the elements commonly form(s) compounds with oxidation state +IV ?
 - b. Which of the elements commonly form(s) compounds with oxidation state +II?
 - c. Which of the elements commonly form(s) compounds with oxidation state +I?

- 4. Let's consider 3d transition metals and their ions:
 - *a*. Show (draw) the relative energies of the different 3d orbitals for a free atom (in gas phase), and for an atom surrounded by anions or ligands in an octahedral coordination.

b. Show how the electrons of the following ions occupy the 3d orbitals in case of octahedral coordination (assume high spin): Ti^{4+} , Ti^{3+} , Mn^{2+} , Cr^{3+} , Fe^{2+} , Fe^{3+}

- *c*. Predict whether the aforementioned ions should be strongly coloured, lightly coloured or colourless (give a short argument in each case).
- 5. From the following list of compounds/materials, select the one(s) which show(s) the given property or characteristics:

K₃[Fe(CN)₆], Fe₂O₃, Fe₃O₄, Hg, BN, B₂H₆, CaTiO₃, Li_xCoO₂, Na_xCoO₂,

La₂CuO₄, (La_{0.9}Sr_{0.1})CuO₄, MoS₂

- a. perovskite
- b. layered crystal structure
- c. metal complex
- d. mixed-valence
- e. superconducting
- f. thermoelectric
- g. antiferromagnetic
- h. isoelectronic with diamond
- i. electron-deficient
- *j*. battery cathode