Chem. 125-126: Feb. 19, 20 and March 3

Experiment 3 Session 2 (Three hour lab)

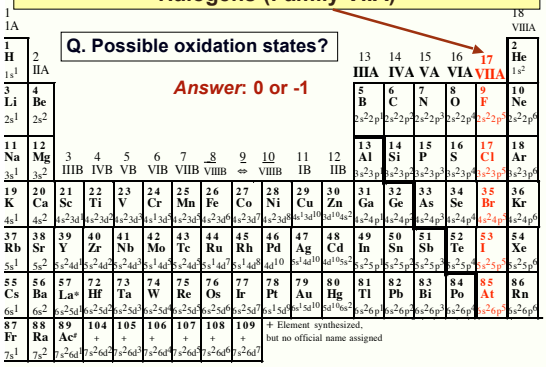
- Complete Experiment 3 Parts 2B and 3
- Complete team report
- Complete discussion presentation

Parts 2A and 2B

- Compare the properties and reactivity of the **halogens and halides**

BACKGROUND INFORMATION

Halogens (Family VIIA)

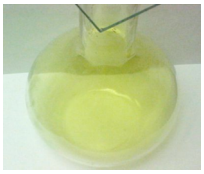


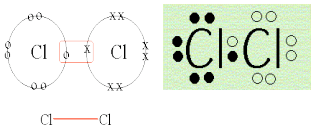
Halogens

Chlorine	Bromine	Iodine
$Cl_2(g)$	$Br_2(l)$	$I_2(s)$

Increasing molecular weight

HALOGENS





Cl_2 = Chlorine

- Exist as diatomic NONPOLAR molecules
- Oxidation state = zero
- Oxidizing agents that react to form halides:
- $Cl_2 + 2\ e^- \rightarrow 2\ Cl^-$

Halogens

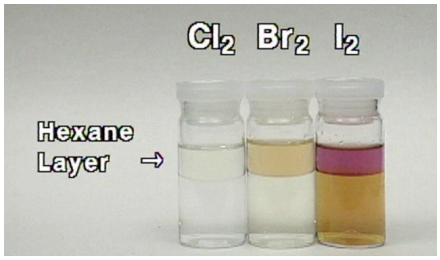
- The halogens will be available in water solution.

Bromine water

Iodine water

- It is difficult to visually distinguish between bromine and iodine water.

Color of the Halogens



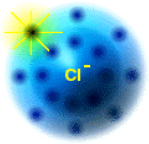
DEMO

• It is possible to visually distinguish between the halogens in hexane where each has distinct colors

Halogens

HALIDES

Cl^- in NaCl(*s*)



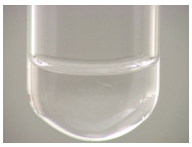
chloride ion

- Exist as anions in salts
- Salt names end in ide (e.g., sodium bromide…)
- Oxidation state = -1.
- Reducing agents

Halides

- The halides are provided as sodium salts in water solution.

Sodium halide (*s*)



Sodium halide (*aq*)

- The sodium salts of the halides visually look the same in the solid state and in aqueous solution.

Sodium salts of the halides

• One cannot visually distinguish between the different halides

Sodium Salts of the Halides

• are soluble in polar solvents (e.g., water).
- are NOT soluble in non-polar solvents (e.g., hexane).

"Like attracts like"

DEMO

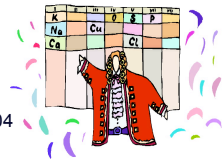
Solvent Extraction

1 - Bromine water + NaBr + hexane
2- Addition of $AgNO_3$ to test for Br^- ions.

DEMO

Part 2B. Reactivity of the Halogens and Halides.

- Collect experimental data on the reactivity:
  - oxidizing agent strength of the halogens
  - reducing agent strength of the halides.
- Compare the halogen reactivity data versus:
  - periodic table position
  - electronegativity values



Discussion questions 3 and 4, p.104

OA Strength of Chlorine versus Bromine?

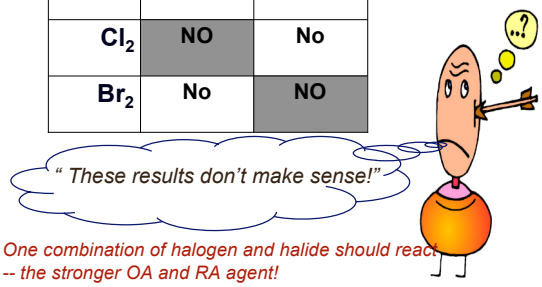
	Cl^-	Br^-
Cl_2	NO	
Br_2		NO

See expanded Table 5, p.84

Table: Oxidizing agents on one side and reducing agents on the other side.

Caution: Check data. Does it make sense?

	Cl^-	Br^-
Cl_2	NO	No
Br_2	No	NO

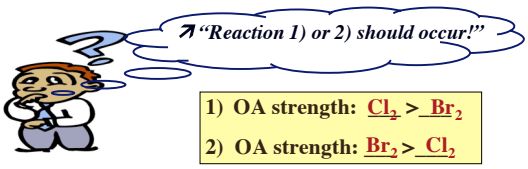


One combination of halogen and halide should react -- the stronger OA and RA agent!

Check Data. Does it make sense?

1) $Cl_2 + 2\,Br^- \rightarrow 2\,Cl^- + Br_2$
   OA RA RA OA

2) $Br_2 + 2\,Cl^- \rightarrow 2\,Br^- + Cl_2$



1) OA strength: $Cl_2 > Br_2$
2) OA strength: $Br_2 > Cl_2$

Q. Based soley on electronegativity values, compare Cl_2 and Br_2 as oxidizing agents?

IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIIIB	IB	IIB	IIIA	IVA	VA	VIA	VIIA
H														
2.1														
Li	Be									B	C	N	O	F
1.0	1.5									2.0	2.5	3.0	3.5	4.0
Na	Mg									Al	Si	P	S	Cl
0.9	1.2									1.5	1.8	2.1	2.5	3.0
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br
0.8	1.0	1.3	1.5	1.6	1.6	1.5	1.8	1.8	1.8	1.9	1.6	1.6	1.8	2.0	2.4	2.8
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I
0.8	1.0	1.2	1.4	1.6	1.8	1.9	2.2	2.2	2.2	1.9	1.7	1.7	1.8	1.9	2.1	2.5
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At
0.7	0.9	-Lu	1.3	1.5	1.7	1.9	2.2	2.2	2.2	2.4	1.9	1.8	1.8	1.9	2.0	2.2
Fr	Ra	Ac	Th	Pa	U	Np-	No									
0.7	0.9	1.1	1.3	1.5	1.7		1.3									

OA: $Cl_2 > Br_2$

Q. Given the fact that $Cl_2 > Br_2$ as an oxidizing agent, indicate the comparative reducing agent strength of Cl^- and Br^-

Oxidizing Agent	Reducing Agent
Cl_2	Cl^-
Br_2	Br^-

Q. Will reaction 1) or 2) below spontaneously occur?

1) $Cl_2(aq) + NaBr\ (aq) \rightarrow$? √

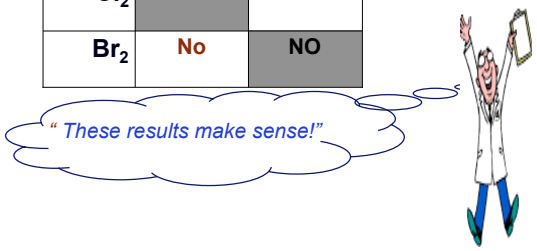
2) $Br_2(aq) + NaCl(aq) \rightarrow$?

Oxidizing Agent	Reducing Agent
Cl_2	Cl^-
Br_2	Br^-

Answer. 1). Cl_2 and Br^- are the stronger OA and RA.

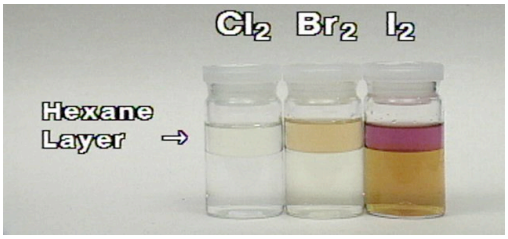
Check data. Does it make sense?

	Cl^-	Br^-
Cl_2	NO	YES
Br_2	No	NO



Experiment Methods

• Compare color of hexane phase in the reaction mixture to that of known halogens (Part 2A) in hexane *to identify the halogen*



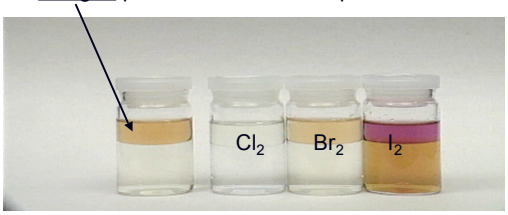
Br_2 (aq) + NaCl (aq) + hexane→ ?

Add Br_2 to NaCl + hexane

Mix the phases

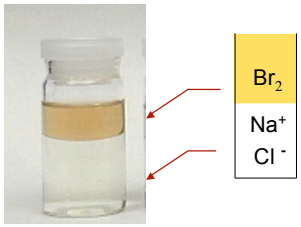
Br_2 (aq) + NaCl (aq) + hexane→ ?

• After mixing the phases, determine the identity of the halogen present in the hexane phase



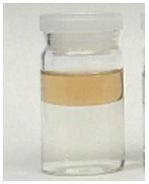
Q. Has reaction occurred? No

Q. Record the identity of the species present in the phases upon addition of hexane to the reaction mixture.



$Br_{2\,(aq)}$ + 2 $NaCl_{(aq)}$ ⟶ no reaction

Q. From results rank the strength of the reducing agents (halides) and the oxidizing agent (halogens).



$Br_{2\,(aq)}$ + 2 $NaCl_{(aq)}$ ⟶ no reaction

RA: Br^- > Cl^- OA: Cl_2 > Br_2

Part 3. Analysis of Redox Reactions

- **Identify reactants and spectators** in redox rxns.
  - Non-reactive redox species (K^+, Na^+, NO_3^-) make good substitutes for an omitted species in tests.
- **Identify products; write a net reaction**
  - Compare products properties to known substances; refer to the *CRC Handbook*.
- Rank the **oxidizing or reducing agent strength** of reaction species

Example: I_2 + $SnCl_2$ → ?

DEMO:

Example: I_2 + $SnCl_2$ → ?

Analysis of Reaction
1. Record Observations



$SnCl_{2(aq)}$ + $I_{2(aq)}$ → clear and colorless product

2. Identify spectator and reactant species.

Reaction: $SnCl_2(aq)$ + $I_2(aq)$ → ?

Reference Blank Test: DEMO

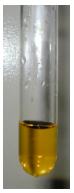


$NaCl_{(aq)}$ + $I_{2(aq)}$ ⟶ no reaction

Conclusion: *"Sn^{2+} is a reactant".*

Reaction: $SnCl_{2(aq)}$ + $I_{2(aq)}$ → ?

Reference Blank Test:


$Sn(NO_3)_{2(aq)}$ + $I_{2(aq)}$ reaction

Conclusion: *"Cl^- is a spectator".*

3) Identify the oxidizing and reducing agent reactants.

Reaction: $SnCl_{2(aq)}$ + $I_{2(aq)}$ → ?

Reactants:

$Sn^{2+}_{(aq)}$ + $I_{2(aq)}$

RA OA

4) Identify Products and Write a Net Reaction

Observation: Light brown $I_{2(aq)}$ color fades.

and thus must form the halide I^-

Knowledge: Sn^{2+} is a reducing agent.

and thus must form Sn^{4+} (rather than Sn^0)

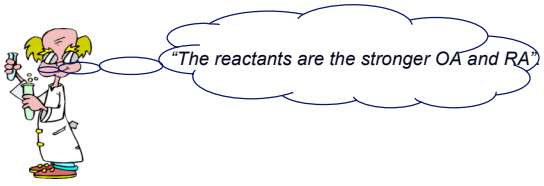
$Sn^{2+}_{(aq)}$ + $I_{2(aq)}$ → $2I^-_{(aq)}$ + $Sn^{4+}_{(aq)}$

5). Strength of the Reducing and Oxidizing Agents?

$Sn^{2+}_{aq)}$ + $I_{2(aq)}$ → $Sn^{4+}_{(aq)}$ + $2I^-_{(aq)}$

RA OA OA RA

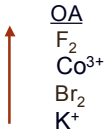
RA strength: Sn^{2+} > I^- OA strength: I_2 > Sn^{4+}



Experiment 3 Exam Question ⟶

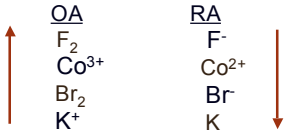
Exam Q. Identify the reactants in the reaction,
$CoF_{3(aq)} + KBr_{(aq)} \rightarrow$?
given OA Strength: **$F_2 > Co^{3+} > Br_2 > K^+$**

- List the OA species and indicate OA strength:



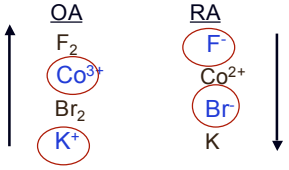
Q. Identify the reactants in the redox reaction,
$CoF_3(aq) + KBr(aq) \rightarrow$?
given OA Strength: $F_2 > Co^{3+} > Br_2 > K^+$

- List the RA species and indicate comparative strength:



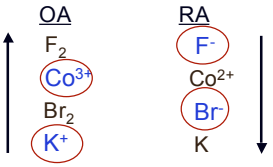
Q. Identify the reactants in the redox reaction,
$CoF_{3(aq)} + KBr_{(aq)} \rightarrow$?
given OA Strength: **$F_2 > Co^{3+} > Br_2 > K^+$**

- Note (circle) all species actually present in the reaction mixture.



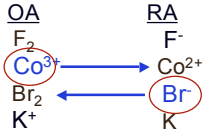
Q. Identify the reactants in the redox reaction,
$CoF_{3(aq)} + KBr_{(aq)} \rightarrow$?
given OA Strength: **$F_2 > Co^{3+} > Br_2 > K^+$**

- Identify the species combinations that will react.



Answer: Co^{3+} and Br^- will react.

Q. Identify the products in the redox reaction,
$CoF_{3(aq)} + KBr_{(aq)} \rightarrow$?
given OA Strength: **$F_2 > Co^{3+} > Br_2 > K^+$**



Answer: $Co^{2+}_{aq)} + Br_{2(aq)}$

Chem 125/126 Hourly I Exam

Practice exam questions!
You should be able to answer all hourly I exam questions upon completion of experiment 3.
Exams on Ctools and the course web site:
http:www.umich.edu/~chem125