

Chem. 125-126: Oct. 8 - Oct. 14

Experiment 3 Session 2 (Three hour lab)

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



Part 2A. Color and Solubility of the Halides and Halogens

- Compare the properties (color and solubility) of the **halides and halogens** in water and hexane.

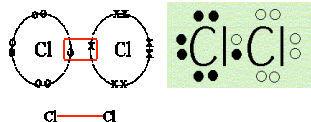
Halogens (Family VIIA)																					
1 1A H 1s ¹	2 IIA He 1s ²	Q. Possible oxidation states? Answer: 0 or -1														18 VIIIA Ne 1s ²					
3 Li 2s ¹	4 Be 2s ²															13 IIIA B 2s ² 2p ¹	14 IVA C 2s ² 2p ²	15 VA N 2s ² 2p ³	16 VIA O 2s ² 2p ⁴	17 VIIA F 2s ² 2p ⁵	18 VIIIA Ne 1s ²
11 Na 3s ¹	12 Mg 3s ²	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 VIIB	9 VIIB	10 VIIB	11 IB	12 IIB	13 IIIA Al 3s ² 3p ¹	14 IVA Si 3s ² 3p ²	15 VA P 3s ² 3p ³	16 VIA S 3s ² 3p ⁴	17 VIIA Cl 3s ² 3p ⁵	18 VIIIA Ar 3s ² 3p ⁶				
19 K 4s ¹	20 Ca 4s ²	21 Sc 3d ¹ 4s ²	22 Ti 3d ² 4s ²	23 V 3d ³ 4s ²	24 Cr 3d ⁵ 4s ¹	25 Mn 3d ⁵ 4s ²	26 Fe 3d ⁶ 4s ²	27 Co 3d ⁷ 4s ²	28 Ni 3d ⁸ 4s ²	29 Cu 3d ¹⁰ 4s ¹	30 Zn 3d ¹⁰ 4s ²	31 Ga 3d ¹⁰ 4s ² 4p ¹	32 Ge 3d ¹⁰ 4s ² 4p ²	33 As 3d ¹⁰ 4s ² 4p ³	34 Se 3d ¹⁰ 4s ² 4p ⁴	35 Br 3d ¹⁰ 4s ² 4p ⁵	36 Kr 3d ¹⁰ 4s ² 4p ⁶				
37 Rb 5s ¹	38 Sr 5s ²	39 Y 4d ¹ 5s ²	40 Zr 4d ² 5s ²	41 Nb 4d ⁴ 5s ¹	42 Mo 4d ⁵ 5s ¹	43 Tc 4d ⁵ 5s ²	44 Ru 4d ⁷ 5s ¹	45 Rh 4d ⁸ 5s ¹	46 Pd 4d ¹⁰ 5s ⁰	47 Ag 4d ¹⁰ 5s ¹	48 Cd 4d ¹⁰ 5s ²	49 In 4d ¹⁰ 5s ² 5p ¹	50 Sn 4d ¹⁰ 5s ² 5p ²	51 Sb 4d ¹⁰ 5s ² 5p ³	52 Te 4d ¹⁰ 5s ² 5p ⁴	53 I 4d ¹⁰ 5s ² 5p ⁵	54 Xe 4d ¹⁰ 5s ² 5p ⁶				
55 Cs 6s ¹	56 Ba 6s ²	57 La* 5d ¹ 6s ²	72 Hf 5d ² 6s ²	73 Ta 5d ³ 6s ²	74 W 5d ⁴ 6s ²	75 Re 5d ⁵ 6s ²	76 Os 5d ⁶ 6s ²	77 Ir 5d ⁷ 6s ²	78 Pt 5d ⁹ 6s ¹	79 Au 5d ¹⁰ 6s ¹	80 Hg 5d ¹⁰ 6s ²	81 Tl 5d ¹⁰ 6s ² 6p ¹	82 Pb 5d ¹⁰ 6s ² 6p ²	83 Bi 5d ¹⁰ 6s ² 6p ³	84 Po 5d ¹⁰ 6s ² 6p ⁴	85 At 5d ¹⁰ 6s ² 6p ⁵	86 Rn 5d ¹⁰ 6s ² 6p ⁶				
87 Fr 7s ¹	88 Ra 7s ²	104 Ac*	105 +	106 +	107 +	108 +	109 +	* Element synthesized, but no official name assigned													

Halogens

Chlorine $\text{Cl}_2(\text{g})$ Bromine $\text{Br}_2(\text{l})$ Iodine $\text{I}_2(\text{s})$

Increasing molecular weight →

HALOGENS



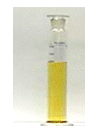
- Exist as diatomic **NONPOLAR** molecules
- Oxidation state = zero
- Oxidizing agents that react to form halides:
 - $\text{Cl}_2 + 2 \text{e}^- \rightarrow 2 \text{Cl}^-$

Halogens

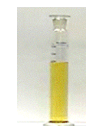
- The halogens will be available in water solution.



Chlorine water



Bromine water



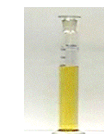
Iodine water

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

Color of the Halogens

- The color of the halogens is solvent dependent.

Example



Iodine water



Iodine in hexane

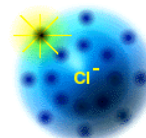
DEMO

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

HALIDES



Cl⁻ in NaCl(s)



chloride ion

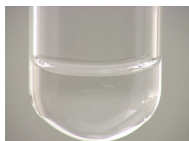
- Exist as anions in salts
- Salt names end in ide (e.g., sodium bromide...)
- Oxidation state = -1.
- Reducing agents

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.

Salt Solubility Reminders

Salts (e.g., halide salts):

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

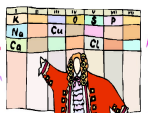


"Like attracts like"

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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

"These results don't make sense!"

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

Interpreting Experiment Results

1) Cl₂ + 2 Br⁻ → 2 Cl⁻ + Br₂
 OA RA RA OA

2) Br₂ + 2 Cl⁻ → 2 Br⁻ + Cl₂

↗ "Reaction 1) or 2) should occur!"

1) OA strength: Cl₂ > Br₂
 2) OA strength: Br₂ > Cl₂

Q. Based solely on electronegativity values, compare Cl₂ and Br₂ as oxidizing agents?

IA	IIA	IIIB	IVB	V	VIB	VII B	VIII B	IB	IIB	IIIA	IVA	VA	VIA	VIIA		
H										B	C	N	O	F		
Li	Be									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: Cl₂ > Br₂

Q. If Cl₂ is a better oxidizing agent than Br₂, should reaction 1) or 2) occur?

1) Cl₂ + 2 Br⁻ → 2 Cl⁻ + Br₂
 OA RA RA OA

2) Br₂ + 2 Cl⁻ → 2 Br⁻ + Cl₂

Answer: Reaction 1)

Q. Based on electronegativity values (chlorine = 3.0 and bromine = 2.8), will the reaction below occur?
 Br₂(aq) + NaCl(aq) → ?

- List the Oxidizing and reducing agent species and indicate the comparative strength

↑ Oxidizing Agent	Reducing Agent ↓
Cl ₂	Cl ⁻
Br ₂	Br ⁻

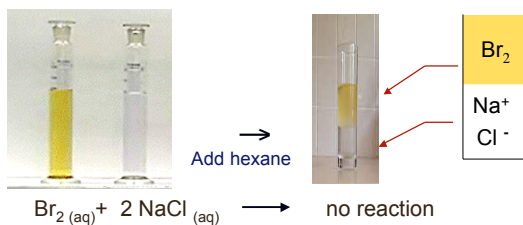
Answer. No. Br₂ and Cl⁻ are the weaker OA and RA.

Experiment:
 Q. Br₂ (aq) + NaCl (aq) → rxn or no rxn?

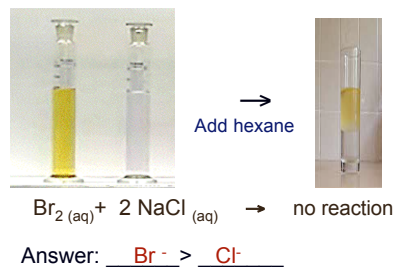
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Br₂ (aq) + 2 NaCl (aq) → **no reaction**

Q2. Identify the species present in the upper and lower phases upon addition of hexane to the reaction mixture.



Q. Based on the experiment results, rank Cl^- and Br^- as reducing agents.



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

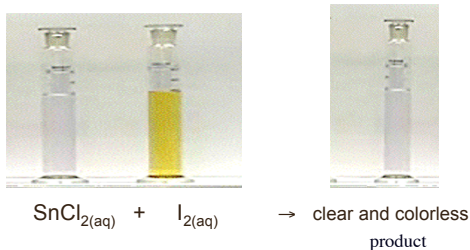
Example: $\text{I}_2 + \text{SnCl}_2 \rightarrow \text{?}$



"Help. I spilled Iodine!"

DEMO: Add tin(II) chloride to iodine spot!

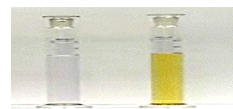
Analysis of Reaction 1. Record Observations



2. Identify spectator and reactant species.

Reaction: $\text{SnCl}_2(\text{aq}) + \text{I}_2(\text{aq}) \rightarrow \text{?}$

Reference Blank Test:



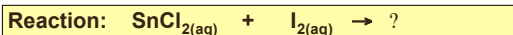
$\text{NaCl}(\text{aq}) + \text{I}_2(\text{aq})$

no reaction

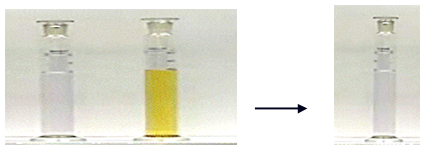
Conclusion:

" Sn^{2+} is a reactant".

DEMO



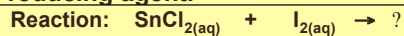
Reference Blank Test:



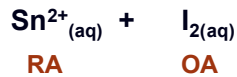
Conclusion:

“Cl⁻ is a spectator”.

3) Identify reactants that = the oxidizing and reducing agent.



Reactants:



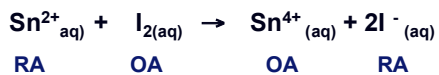
4) Identify Products and Write a Net Reaction

Observation: Light brown $\text{I}_{2(aq)}$ 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)



5). Strength of the Reducing and Oxidizing Agents?

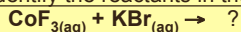


RA strength: $\text{Sn}^{2+} > \text{I}^-$ OA strength: $\text{I}_2 > \text{Sn}^{4+}$



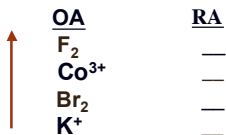
“The reactants are the stronger OA and RA”

Exam Q. Identify the reactants in the reaction,



given OA Strength: $\text{F}_2 > \text{Co}^{3+} > \text{Br}_2 > \text{K}^+$

▪List the species and indicate OA and RA strength:

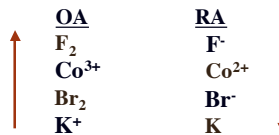


Q. Identify the reactants in the redox reaction,

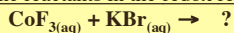


given OA Strength: $\text{F}_2 > \text{Co}^{3+} > \text{Br}_2 > \text{K}^+$

▪List the species and indicate OA and RA strength:

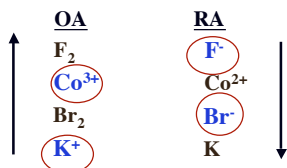


Q. Identify the reactants in the redox reaction.

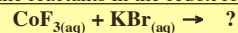


given OA Strength: $\text{F}_2 > \text{Co}^{3+} > \text{Br}_2 > \text{K}^+$

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

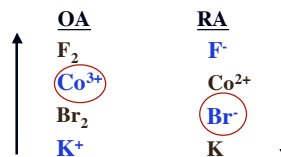


Q. Identify the reactants in the redox reaction.



given OA Strength: $\text{F}_2 > \text{Co}^{3+} > \text{Br}_2 > \text{K}^+$

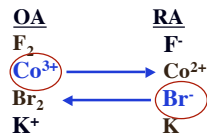
▪ Identify (circle) which species will react based on above oxidizing agent (OA) strength



Q. Identify the products in the redox reaction.



given OA Strength: $\text{F}_2 > \text{Co}^{3+} > \text{Br}_2 > \text{K}^+$



Answer: $\text{Co}^{2+}_{(\text{aq})} + \text{Br}_{2(\text{aq})}$

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>

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