

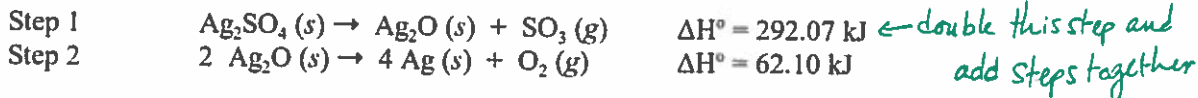
name KEYScored grade (instructor use only!) 100

For all calculation questions, show your work in the space provided, and write your answer on the line.
Round numerical values appropriately and include unit(s).

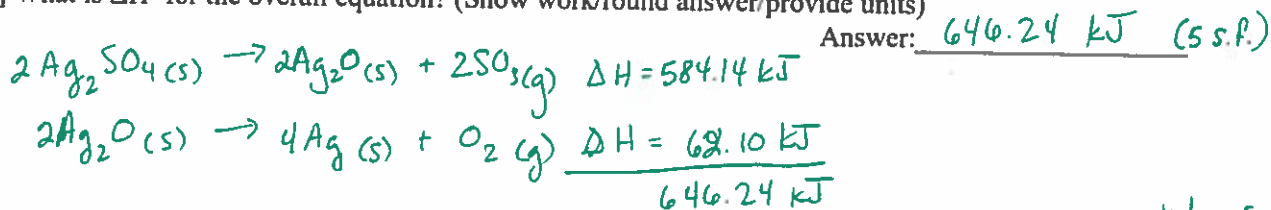
1. At high temperature, silver sulfate reacts to form Ag metal, SO_3 and O_2 . The overall equation is the following.

$$2 \text{Ag}_2\text{SO}_4 (s) \rightarrow 2 \text{SO}_3 (g) + 4 \text{Ag} (s) + \text{O}_2 (g)$$

Consider this overall reaction as derived from two Steps:



- ** (a) [4 pts] What is ΔH° for the overall equation? (Show work/round answer/provide units)



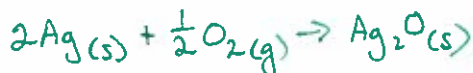
\leftarrow note: keeping 2 decimal places gives 5 s.f. in answer

- (b) [1 pt] Is the overall reaction exothermic or endothermic? endothermic ($\Delta H > 0$)

(answer must be consistent with your answer in (a))

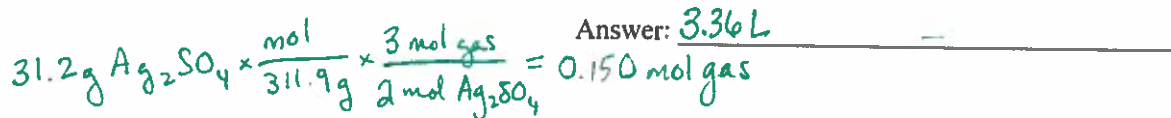
- (c) [1 pt] Ag_2O , in this reaction, is formed and then consumed, and does not appear in the overall equation. What is the term used to describe a species like this? intermediate

- (d) [2 each] What is the value of ΔH_f° for each of the species below? (Include appropriate unit(s).)



- (e) If 31.2 g of Ag_2SO_4 reacts according to the overall equation above, and the collected product gas mixture from the reaction is cooled to STP:

- i. [4 pts] What is the total volume of the gaseous products? (Show work/round answer/provide units)



$$V = \frac{nRT}{P} = \frac{(0.150 \text{ mol})(0.08206 \frac{\text{L} \cdot \text{atm}}{\text{K} \cdot \text{mol}})(273 \text{ K})}{1 \text{ atm}} = 3.36 \text{ L}$$

- ii. [3 pts] What is the pressure of the SO_3 gas in the mixture? (Hint: try to think of a simple way to approach this question.)

Total $P = 1 \text{ atm}$

Answer: 0.667 atm

SO_3 is $\frac{2}{3}$ of that, so 0.667 atm

- (f) [2 pts] Which element is oxidized in the overall reaction? O (goes from -2 to \emptyset)

name KEY

2. [2 each] Supply an appropriate example of each of the following. In some cases there could be more than one acceptable answer; pick one.

Cs

An element with valence electrons in the $n=6$ energy level. Any Period 6 element; any Period 7 element in d block

 ϕ

An allowed value of m_l for an electron in the $4s$ sublevel. in S, $l = \phi$, m_l can only be ϕ

I (I_{2(g)})

An element that exists under standard conditions as diatomic molecules in the solid state.

Be

A neutral atom with 2 valence electrons. any Group 2 element ^(I)any gen or -ine element ^(D)Br_{2(s)}, I_{2(s)}

Hs

A neutral atom with 6 electrons in the 6d sublevel.

Cr

A neutral atom with 4 unpaired electrons. Any Group 6 or Group 8, Ni, U, Er, Fm

2

The electron capacity of a single 13h orbital. any single orbital can hold 2e⁻

Ne

The Period 2 element with the largest value for IE₁. IE increases →

He

A neutral atom that is diamagnetic. Any Group 2, Group 12, Group 18

5

The number of unpaired electrons in a Mn²⁺ ion. Mn²⁺: $\begin{array}{c} 1 \ 1 \ 1 \ 1 \ 1 \\ 4s \quad 3d \end{array}$

3. [2 each] Clearly indicate whether each statement is TRUE or FALSE. If we can't tell which you mean, it's wrong.

false

An electron transition from $n=5$ to $n=3$ ~~absorbs~~ ^{emits} a photon.

false

The energy of a photon is determined by its ~~amplitude~~. λ or ν

false

Gases behave most ideally when the ~~temperature~~ and pressure are both low. ^{better at high temp}

true

Under similar conditions, lighter gases effuse and diffuse more quickly than heavier gases.

true

Most elements are metals.

true

Most elements are solid at room temperature.

true

Most elements are paramagnetic as individual atoms.

true

The 5d sublevel has five orbitals.

true

O²⁻ and Na⁺ have the same electron configuration. ^{both isoelectronic with Ne}

true

O²⁻ has a larger ionic radius than Na⁺. ^{same e⁻ config, but O has +8 nuclear charge and Na has +11.}

true

In an exothermic reaction, energy flows from a system into the surroundings.

20

22

42

name KEY

4. [1 each] Air is mostly made up of a mixture of about 80% nitrogen gas and 20% oxygen gas. Consider a balloon filled with air. Answer each question below by circling the appropriate answer.

- a. Which gas has a greater partial pressure? 80% N₂ O₂ N₂ both the same
- b. Which has the greater average kinetic energy? Same sample O₂ N₂ both the same
Same T
- c. Which has a faster average molecular speed? lighter molecules O₂ N₂ both the same
have faster speed at same energy
- d. If the balloon develops a slow leak, which gas's concentration will increase in the balloon? N₂ will leak out faster, O₂ concentration will increase in balloon O₂ N₂ both neither
- e. If the balloon develops a slow leak, what will happen to each parameter for the sample in the balloon?
 n: molecules are leaving increase decrease no change
 P: balloon pressure is determined by outside pressure increase decrease no change
 V: balloon shrinks increase decrease no change
 density: increase decrease no change
mixture in balloon is becoming enriched in O₂, the heavier gas

5. [2 each] For each of the following, select the **greatest** value and circle your choice.

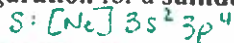
- a. radius: Al³⁺ < Al and Si < Al Al Al³⁺ Si all the same
- b. number of orbitals: 5 in any d in 3d sublevel in 4d sublevel in 5d sublevel all the same
- c. energy of photon of light: E = hc/λ 10 nm 400 nm 700 nm all the same
- d. number of valence electrons: O 6 P 5 Ge 4 all the same
- e. number of unpaired electrons: N 111 O 222 F 111 all the same
- f. first ionization energy: IE₁ increases → Li Be B all the same
- g. second ionization energy: Li from n=1 Be from n=2 B from n=2 all the same
- h. effective nuclear charge for valence e : Cl 7 Ar 8 K 1 all the same
- i. effective nuclear charge for valence e : Cl 7 Ar 8 K 9 all the same

name KEY

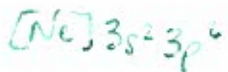
6. [3 each] Write each answer in the box provided.

a. Give the ground-state valence **orbital diagram** (or "box diagram") for a **chromium(II) ion**.

a.

b. Give the ground-state, condensed **electron configuration** for a **sulfide ion**.

b.

c. Give the ground-state, condensed **electron configuration** for a **gallium atom**.

c.

7. [4] If an He^+ ion has its electron in the $n=3$ level, what is the maximum **wavelength** of electromagnetic radiation required to remove the electron from the ion? (Show work/round answer/include units)Answer: $2.05 \times 10^{-7} \text{ m}$ or 205 nm

$$E = -2.18 \times 10^{-18} \text{ J} \left(\frac{-Z^2}{n^2} \right) = -2.18 \times 10^{-18} \text{ J} \left(\frac{1^2}{3^2} \right)$$

$$= -2.18 \times 10^{-18} \left(\frac{1}{9} \right)$$

$$= -9.69 \times 10^{-19} \text{ J} = \text{Energy of electron} \rightarrow \text{energy to}$$

remove e^- is a positive value \rightarrow

$$+9.69 \times 10^{-18} \text{ J} = \text{energy of photon}$$

$$E_{\text{photon}} = \frac{hc}{\lambda}$$

$$\lambda = \frac{hc}{E} = \frac{(6.626 \times 10^{-34} \text{ J}\cdot\text{s})(3.00 \times 10^8 \text{ m/s})}{9.69 \times 10^{-18} \text{ J}} = 2.05 \times 10^{-7} \text{ m} \times \frac{10^9 \text{ nm}}{\text{m}}$$

$$= 205 \text{ nm}$$