

## Chemistry 1210 Spring 2023 Test 2

Wednesday, March 1, 2023

Time: 1 hour 50 minutes

Name: ANSWERS

Student #: \_\_\_\_\_

This test consists of **six** pages of questions, the formula sheet, and a periodic table. Please ensure that you have a complete test and, if you do not, obtain one from me **immediately**. There are **37** marks available. Good luck!

1) [2 marks] The molar solubility of  $\text{Ca}_3(\text{PO}_4)_2$  in water is  $1.14 \times 10^{-7}$ . The  $K_{\text{sp}}$  of  $\text{Ca}_3(\text{PO}_4)_2$  should therefore be:

a)  $1.92 \times 10^{-35}$

b)  $6.9 \times 10^{-34}$

c)  $2.07 \times 10^{-33}$

d)  $1.3 \times 10^{-14}$

e)  $7.78 \times 10^{-14}$

2) [2 marks] The  $K_{\text{sp}}$  of  $\text{Ag}_3\text{PO}_4$  is  $8.89 \times 10^{-17}$ , and the molar mass of  $\text{Ag}_3\text{PO}_4$  is 418.6 grams. The number of grams of  $\text{Ag}_3\text{PO}_4$  that will dissolve in 1 litre of 0.010 M  $\text{AgNO}_3$  is therefore:

a)  $3.0 \times 10^{-15}$

b)  $8.9 \times 10^{-15}$

c)  $3.3 \times 10^{-12}$

d)  $3.7 \times 10^{-12}$

e)  $8.9 \times 10^{-11}$

f)  $3.7 \times 10^{-8}$

- 3) [4 marks] A solution contains  $[S^{2-}] = 1.0 \times 10^{-10} \text{ M}$  and  $[PO_4^{3-}] = 1.0 \times 10^{-2} \text{ M}$ . Solid  $AgNO_3$  is added carefully to separate the two ions. The  $K_{sp}$ s of the two compounds formed are  $8.89 \times 10^{-17}$  ( $Ag_3PO_4$ ) and  $1.6 \times 10^{-49}$  ( $Ag_2S$ ).

a) Which ion will precipitate first?

$$S^{2-}: 1.6 \times 10^{-49} = [Ag^+]_c^2 \cdot 1 \times 10^{-10} \Rightarrow [Ag^+]_c = 4 \times 10^{-20} \text{ M}$$

$$PO_4^{3-}: 8.89 \times 10^{-17} = [Ag^+]_c^3 \cdot 1 \times 10^{-2} \Rightarrow [Ag^+]_c = 2.07 \times 10^{-5}$$

So  $S^{2-}$  precipitates first

b) At the point of maximum separation, what will be the percent remaining of the first ion to precipitate?

$$(2.07 \times 10^{-5})^2 \cdot [S^{2-}]_c = 1.6 \times 10^{-49}$$

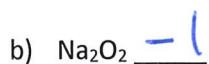
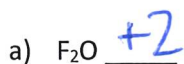
$$\Rightarrow [S^{2-}]_c = 3.728 \times 10^{-40} \text{ M}$$

↑ small!  
↑ wow!

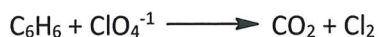
$$\% \text{ remaining: } \frac{3.728 \times 10^{-40}}{1 \times 10^{-10}} \times 100 = 3.728 \times 10^{-28} \%$$

↑ wow!  
↑ small!

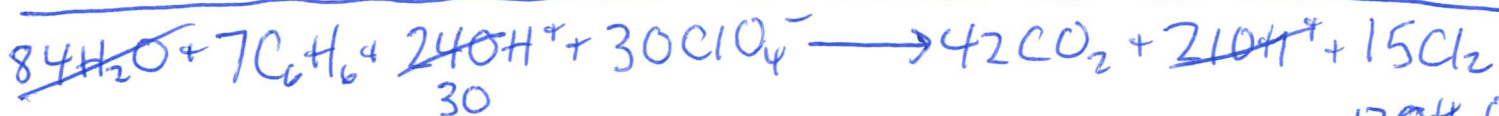
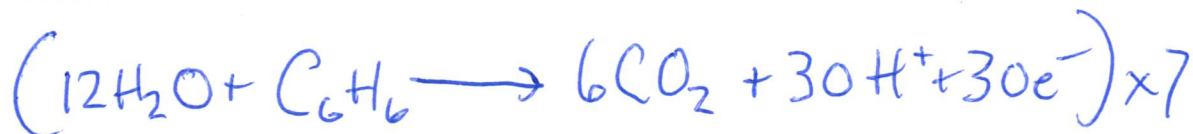
4) [4 marks] Give the oxidation number of the oxygen atom in each of the following compounds:



5) [7 marks total] Given the following (unbalanced) redox reaction, occurring in basic solution:



a) [4 marks] Balance the reaction.



b) [1 mark] Identify the reducing agent.



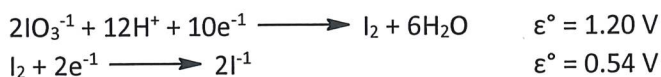
c) [1 mark] Identify the species which is oxidized.



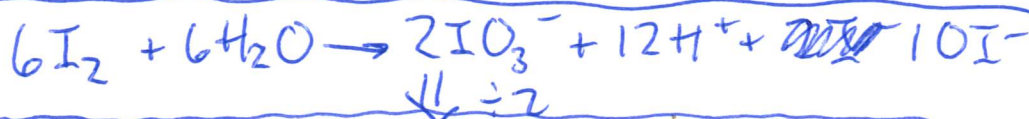
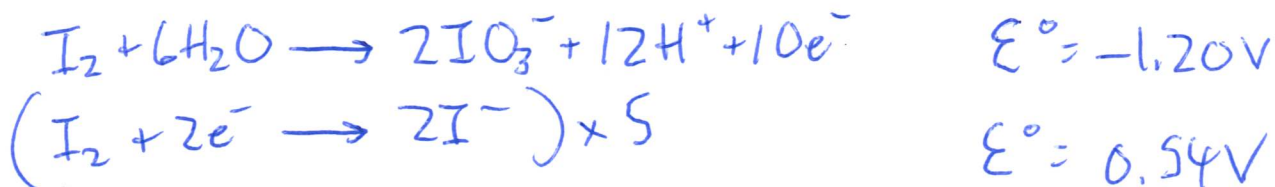
d) [1 mark] How many electrons are transferred in the overall process?

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6) [5 marks total] Given the following half-reactions:



a) [2 marks] Write the reaction for the disproportionation of  $\text{I}_2$ .



b) [1 mark] Will  $\text{I}_2$  disproportionate under standard conditions? How do you know? (No marks for guessing. 😊)

$$0.54 - 1.20 = -0.66 \text{ V for } \epsilon^\circ$$

$$\epsilon^\circ < 0, \text{ so } \boxed{\text{NO}}$$

c) [2 marks] Calculate  $K_c$  for the disproportionation. You may assume a temperature of  $25^\circ\text{C}$ .

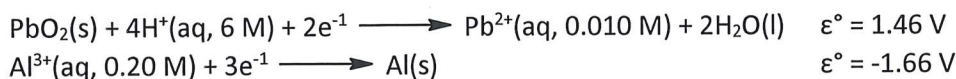
$$0 = -0.66 - \frac{0.059159}{5} \log K$$

b/c divided by 2 above.

$$\Rightarrow \boxed{K = 1.65 \times 10^{-56}}$$

$$(\text{If didn't } \div 2, \text{ get } 2.73 \times 10^{-112})$$

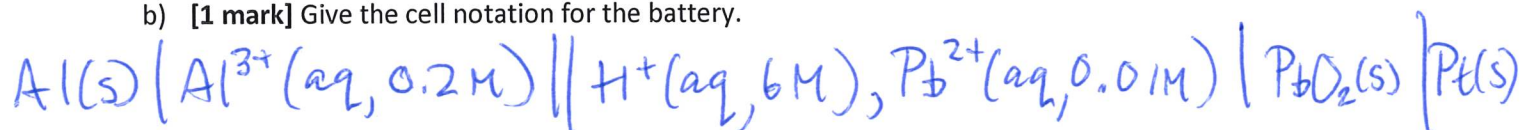
7) [9 marks total] A battery was constructed using the following half-reactions:



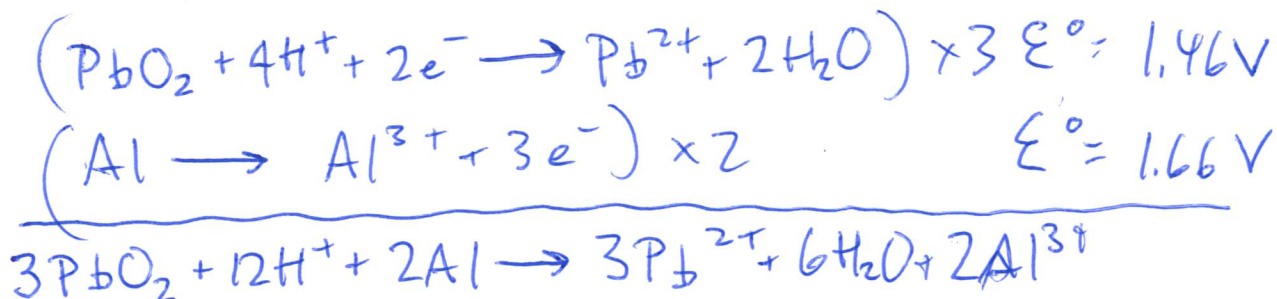
The battery was run at 25°C, and 2 litres of solution were used in each half-cell. Platinum electrodes were available for use as necessary.

a) [1 mark] Which electrode will be the anode?  $\text{Al}(\text{s})$

b) [1 mark] Give the cell notation for the battery.



c) [1 mark] What is the overall reaction occurring in the battery?



d) [1 mark] What voltage will the battery produce under standard conditions?

$$1.46 + 1.66 = \boxed{3.12 \text{ V}}$$

e) [2 marks] What voltage will the battery produce under the conditions given?

$$\begin{aligned} \epsilon &= 3.12 - \frac{0.059159}{6} \log \left( \frac{0.01^3 \cdot 0.2^2}{6^{12}} \right) \\ &= \boxed{3.285 \text{ V}} \end{aligned}$$



- f) [3 marks] A current of 0.50 A was drawn from the battery for 3 hours and 13 minutes. What was the concentration of the  $\text{Al}^{3+}$  at the end of this time?

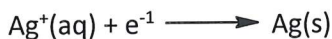
$$0.5 \frac{\text{Coul}}{\text{s}} \times 11580 \text{s} \times \frac{1 \text{ mole } e^-}{96,485 \text{ Coul}} \times \frac{1 \text{ Al}^{3+}}{3 e^-}$$

$$= 0.02 \text{ mol Al}^{3+} \text{ created}$$

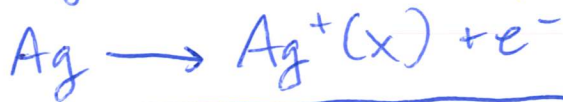
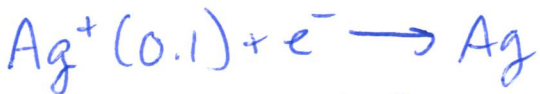
~~2.2~~ 
$$2 \text{ L} \times \frac{0.2 \text{ moles}}{\text{L}} + 0.02 \text{ mol}$$

$$\frac{\quad}{2 \text{ L}} = \boxed{0.21 \text{ M}}$$

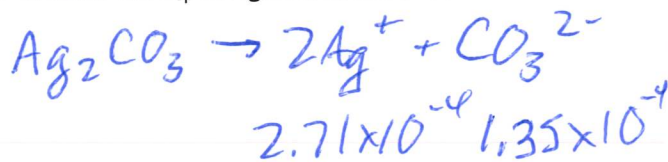
- 8) [4 marks] A concentration cell was assembled based on the following half-reaction:



One half cell contained a 0.10 M solution of  $\text{AgNO}_3$ , and the other held a saturated solution of  $\text{Ag}_2\text{CO}_3$ . The cell, when run at  $35.17^\circ\text{C}$ , produced 0.157 volts. What is the  $K_{\text{sp}}$  of  $\text{Ag}_2\text{CO}_3$  at  $35.17^\circ\text{C}$ ?



$$Q = \frac{x}{0.1}$$



$$K_{\text{sp}} = (2.71 \times 10^{-4})^2 (1.35 \times 10^{-4})$$

$$= \boxed{1 \times 10^{-11}}$$

$$0.157 = 0 - \frac{(8.314)(308.32)}{1.96,485 \dots} \ln Q$$

$$\Rightarrow Q = 2.71 \times 10^{-3}; [\text{Ag}^+]_6 = 2.71 \times 10^{-4}$$