

## Chemistry 1210 Spring 2024 Test 3

Wednesday, March 27, 2024

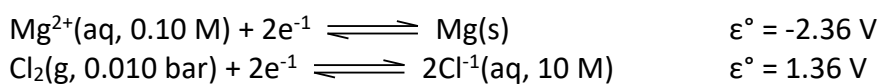
Time: 1 hour 50 minutes

Name: \_\_\_\_\_

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

*This test consists of **ten** 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 **43** marks available. Good luck!*

1) **[11 marks total]** A battery was constructed using the following half-reactions:



Platinum electrodes were available where necessary, and 3 litres of solution were used in each half cell. The battery was run at 25°C.

a) **[1 mark]** Write the overall reaction occurring in the battery.

b) **[1 mark]** Calculate  $\epsilon^{\circ}$  for the battery.

c) **[2 marks]** Calculate K for the battery.

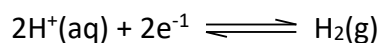
d) **[2 marks]** What voltage will the battery generate under the conditions given?

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

f) **[3 marks]** A current of 2.0 amperes was drawn from the battery for 16 hours, 4 minutes, and 51.2 seconds. What was the  $[\text{Mg}^{2+}]$  after that time?

g) **[1 mark]** This battery cannot be recharged successfully. Why? (No marks for guessing.  
☺)

2) **[4 marks]** A concentration cell was set up using the half-reaction:



Both half-cells had the pressure of  $\text{H}_2$  set to 0.20 bar. In one of the half cells the  $[\text{H}^+]$  was 0.10 M, and in the other the  $\text{H}^+$  was generated by a 0.035 M solution of a weak acid. The concentration cell was run at  $10.06^\circ\text{C}$ . If the battery so constructed generated 46.3 mV, what was the  $K_a$  of the weak acid?

3) **[1 mark]** Which of the following species is most likely to be amphiprotic?

a)  $\text{NH}_3$

b)  $\text{H}_3\text{PO}_4$

c)  $\text{C}_2\text{H}_3\text{O}_2^{-1}$

d)  $\text{H}_2\text{AsO}_4^{-1}$

4) **[2 marks]** When  $K_w = 1.0 \times 10^{-13}$ , the pH of a  $3 \times 10^{-10}$  M solution of  $\text{Mg}(\text{OH})_2$  is closest to:

a) 3.48

c) 6.50

e) 9.52

b) 3.78

d) 9.22

f) None of these

5) **[11 marks total]** Calculate the pH of the following solutions, all made at  $25^\circ\text{C}$ :

a) **[3 marks]** 10.0 mL of  $1.0 \times 10^{-3}$  M HBr mixed with 15.0 mL of  $5.0 \times 10^{-4}$  M KOH.

b) **[3 marks]** 10.0 mL of a solution that has  $[HA] = 0.20\text{ M}$  and  $[NaA] = 0.10\text{ M}$  mixed with 15.0 mL of 0.05 M NaOH. HA is a weak acid with a  $K_a = 1.40 \times 10^{-4}$

c) **[3 marks]** 0.014 M NaA (same weak acid as in (b)).

d) **[2 marks]** 10.0 mL of 0.20 M  $\text{NH}_3$  ( $K_b = 1.74 \times 10^{-5}$ ) mixed with 15.0 mL of 0.1335 M HI.

6) **[14 marks total]**  $\text{H}_2\text{A}$  is a weak acid with  $K_{a1} = 2.5 \times 10^{-4}$  and  $K_{a2} = 4.0 \times 10^{-9}$ . Calculate the pH of the following solutions made using  $\text{H}_2\text{A}$  and/or its salts at  $25^\circ\text{C}$ .

a) **[3 marks]** 10.0 mL of 0.18 M  $\text{H}_2\text{A}$  mixed with 15.0 mL of 0.30 M NaHA.

b) **[2 marks]** 15.0 mL of 0.30 M NaHA



c) **[4 marks]** 10.0 mL of 0.21 M  $\text{H}_2\text{A}$  mixed with 15.0 mL of 0.18 M NaOH

d) **[1 mark]** What would be the  $\text{pK}_a$  for an indicator that you would use for the titration of  $\text{H}_2\text{A}$ ? How do you know? (No marks for guessing. 😊)

e) **[4 marks]** Sketch the titration curve you would expect to see for  $\text{H}_2\text{A}$  being titrated by  $\text{NaOH}$ . On your graph, indicate:

- i) The equivalence point or points
- ii) The buffer region or regions
- iii) The region or regions on the graph where the pH is controlled by  $\text{OH}^-$
- iv) The point or points on the graph where the pH is controlled by one amphoteric species.