

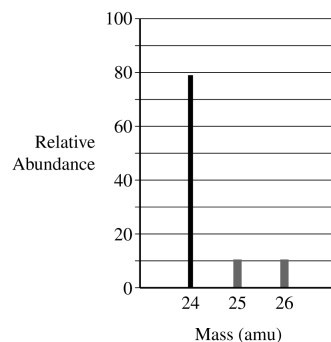
Question 1: Long Answer

10 points

A (i) For the correct plotted lines:

Point 01

The abundance for the two lines should be between 10 and 11.



(ii) For the correct answer:

Point 02

Magnesium-26 has one more neutron than magnesium-25 does.

B (i) For a correct explanation:

Point 03

The charge on the sodium ion is less than the charge on the magnesium ion. A smaller charge results in a weaker Coulombic attraction between Na^+ and water.

(ii) For a correct explanation:

Point 04

The Na^+ ion is larger than the Mg^{2+} ion, so the distance between the Na^+ and the oxygen on the water molecule will be greater. As distance increases, Coulombic attraction decreases.

C For the correct calculated value:

Point 05

$$\text{pOH} = -\log(2.80 \times 10^{-4}) = 3.553$$

$$\text{pH} = 14 - \text{pOH} = 14 - 3.553 = 10.447$$

D For the correct calculated value:

Point 06

$$M_1V_1 = M_2V_2$$

$$M_2 = \frac{(1.85 \times 10^{-3} M)(0.03500 \text{ L})}{(0.03500 \text{ L} + 0.05000 \text{ L})} = 7.62 \times 10^{-4} M$$

E (i) For the correct expression:

Point 07

$$K_{sp} = [\text{Mg}^{2+}][\text{OH}^-]^2$$

(ii) For the correct calculated value, consistent with part D and part E (i):

Point 08

$$Q = [\text{Mg}^{2+}][\text{OH}^-]^2 = (7.62 \times 10^{-4})(1.65 \times 10^{-4})^2 = 2.07 \times 10^{-11}$$

(iii) For the correct prediction and justification, consistent with part E (ii).

Point 09

Examples of acceptable responses may include the following:

- $Q > K_{sp}$, so a precipitate will form.
- The concentration of the ions in solution (represented by Q) is greater than that of a saturated solution, so a precipitate will form.

F For the correct answer and justification:

Point 10

Decrease. The H^+ from $\text{HNO}_3(aq)$ will react with OH^- , decreasing $[\text{OH}^-]$ and causing $Q < K_{sp}$. As a result, more $\text{Mg}(\text{OH})_2(s)$ will dissolve until equilibrium is reestablished, resulting in less $\text{Mg}(\text{OH})_2(s)$.

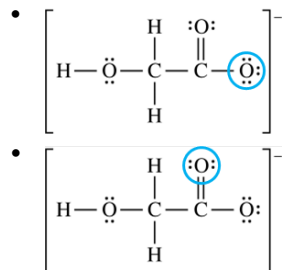
4 points

Question 7: Short Answer

A For a correct circled atom.

Point 01

Accept one of the following:



(Because of resonance, the two C–O bonds on the right are equivalent.)

B (i) For the correct calculated value:

Point 02

$$K_b = \frac{[\text{HC}_2\text{H}_3\text{O}_3][\text{OH}^-]}{[\text{C}_2\text{H}_3\text{O}_3^-]} = \frac{(1.3 \times 10^{-5})(1.3 \times 10^{-5})}{(2.5 - 1.3 \times 10^{-5})} \approx \frac{(1.3 \times 10^{-5})^2}{(2.5)} = 6.8 \times 10^{-11}$$

(ii) For the correct calculated value, consistent with part B (i):

Point 03

$$K_a = \frac{K_w}{K_b} = \frac{1.0 \times 10^{-14}}{6.8 \times 10^{-11}} = 1.5 \times 10^{-4}$$

C For the correct answer and a valid justification:

Point 04

Agree. H_3O^+ is consumed in step 1 and regenerated in step 2, which is consistent with the behavior of a catalyst.

4 points

Question 5: Short Answer

(a) (i) For the correct calculated value:

1 point

$$n = \frac{PV}{RT} = \frac{(7.45 \text{ atm})(6.00 \text{ L})}{(0.08206 \frac{\text{L}\cdot\text{atm}}{\text{mol}\cdot\text{K}})(296 \text{ K})} = 1.84 \text{ mol}$$

(ii) For the correct calculated value:

1 point

Accept one of the following:

- $$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

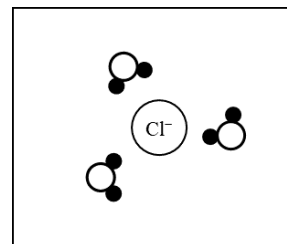
$$P_2 = \frac{(P_1)(T_2)}{T_1} = \frac{(7.45 \text{ atm})(271 \text{ K})}{296 \text{ K}} = 6.82 \text{ atm}$$
- $$P = \frac{nRT}{V} = \frac{(1.84 \text{ mol})(0.08206 \frac{\text{L}\cdot\text{atm}}{\text{mol}\cdot\text{K}})(271 \text{ K})}{6.00 \text{ L}} = 6.82 \text{ atm}$$

Total for part (a) 2 points

(b) For a correct drawing:

1 point

The drawing should show three water molecules with a hydrogen atom (dark circle) oriented towards the Cl^- ion.



(c) For the correct answer and a valid justification:

1 point

HNO_2 . The diagram shows most of the molecules in their un-ionized form, indicating a weak acid with a K_a value less than 1, which is consistent with HNO_2 .

Total for question 5 4 points