## Ch. 4 practice questions

1. Identify the precipitate(s) formed (if any) if we mix aqueous solutions of $Pb(ClO_4)_2$ and $Na_2SO_4$.
   A) $Pb(ClO_4)_2$
   B) $NaClO_4$
   C) $PbSO_4$
   D) $Pb_2(SO_4)_2$
   E) No precipitate

2. How many grams of $BaCl_2$ must be dissolved to make 1.90 L solution of 0.0521 *M* $Cl^-$? (Molar mass of $BaCl_2$ = 208.23 g/mol)
   A) 5.42 g
   B) 21.7 g
   C) 0.175 g
   D) 10.3 g
   E) 41.2 g

3. Element X is not among the elements explicitly mentioned in the rules on oxidation states. In which of the following species does X have the lowest oxidation state?
   A) XOF
   B) $X_2O_2Cl_4$
   C) $X_2O_2F^{2+}$
   D) $XO_2Cl_3{}^{2-}$
   E) $X_2OI^-$

4. What is the complete ionic equation for the reaction that occurs if we mix aqueous solutions of $Zn(ClO_4)_2$ and KOH?

A) $Zn^{2+}(aq) + 2\ ClO_4^-(aq) + 2K^+(aq) + 2OH^-(aq) \rightarrow Zn(OH)_2(s) + 2K^+(aq) + 2ClO_4^-(aq)$

B) $Zn^{2+}(aq) + 2OH^-(aq) \rightarrow Zn(OH)_2(s)$

C) $Zn(ClO_4)_2(aq) + 2KOH(aq) \rightarrow Zn(OH)_2(s) + 2KClO_4(aq)$

D) $Zn^{2+}(aq) + 2ClO_4^-(aq) + 2K^+(aq) + 2OH^-(aq) \rightarrow Zn^{2+}(aq) + 2OH^-(aq) + 2K^+(aq) + 2ClO_4^-(aq)$

E) Zn2+(aq) + 2OH–(aq) $\rightarrow$ $Zn(OH)_2(aq)$

5. What is the molecular equation for the reaction that occurs if we mix aqueous solutions of $AgNO_3$ and CsOH?

A) $Ag^+(aq) + NO_3^-(aq) + Cs^+(aq) + OH^-(aq) \rightarrow AgOH(s) + Cs^+(aq) + NO_3^-(aq)$

B) $Ag^+(aq) + OH^-(aq) \rightarrow AgOH(s)$

C) $AgNO_3(aq) + CsOH(aq) \rightarrow AgOH(s) + CsNO_3(aq)$

D) $Ag^+(aq) + NO_3^-(aq) + Cs^+(aq) + OH^-(aq) \rightarrow Ag^+(aq) + OH^-(aq) + Cs^+(aq) + NO_3^-(aq)$

E) Ag+(aq) + OH–(aq) $\rightarrow$ AgOH(aq)

6. What is the net ionic equation for the reaction that occurs if we mix aqueous solutions of $AgNO_3$ and $Rb_3PO_4$?

A) $3Ag^+(aq) + 3\ NO_3^-(aq) + 3Rb^+(aq) + PO_4^{3-}(aq) \rightarrow Ag_3PO_4(s) + 3Rb^+(aq) + 3NO_3^-(aq)$

B) 3Ag+(aq) + PO43–(aq) $\rightarrow$ $Ag_3PO_4(aq)$

C) $3AgNO_3(aq) + Rb_3PO_4(aq) \rightarrow Ag_3PO_4(s) + 3RbNO_3(aq)$

D) $3Ag^+(aq) + 3NO_3^-(aq) + 3Rb^+(aq) + PO_4^{3-}(aq) \rightarrow Ag^+(aq) + PO_4^{3-}(aq) + 3Rb^+(aq) + 3NO_3^-(aq)$

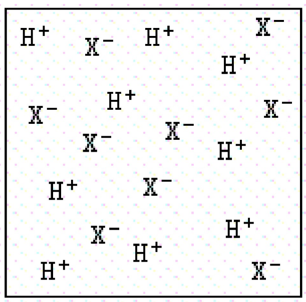
E) $3Ag^+(aq) + PO_4^{3-}(aq) \rightarrow Ag_3PO_4(s)$

7. Which of the following is a strong acid?

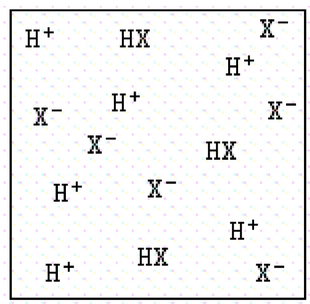
A) HF
B) KOH
C) $HClO_4$
D) HClO
E) HBrO

8. Which of the following is *not* a strong base?
   A) $Ca(OH)_2$
   B) KOH
   C) $NH_3$
   D) LiOH
   E) $Sr(OH)_2$

9. A solid acid HX is mixed with water. Two possible solutions can be obtained. Which of the following is true?



I.



II.

   A) In case I, HX is acting like a weak acid, and in case II, HX is acting like a strong acid.
   B) In case I, HX is acting like a strong acid, and in case II, HX is acting like a weak acid.
   C) In both cases, HX is acting like a strong acid.
   D) In both cases, HX is acting like a weak acid.
   E) HX is not soluble in water.

10. A 38.1-g sample of $SrCl_2$ is dissolved in 112.5 mL of solution. Calculate the molarity of this solution.
   A) 27.0 *M*
   B) 2.14 *M*
   C) 53.7 *M*
   D) 0.339 *M*
   E) none of these

11. A 74.28-g sample of $Ba(OH)_2$ is dissolved in enough water to make 2.450 liters of solution. How many mL of this solution must be diluted with water in order to make 1.000 L of 0.100 *M* $Ba(OH)_2$? (Molar mass of $Ba(OH)_2$ is 171.34 g/mol)
A) 565 mL
B) 177 mL
C) 17.7 mL
D) 4.34 mL
E) 231 mL

12. What volume of 18 *M* sulfuric acid must be used to prepare 2.30 L of 0.145 *M* $H_2SO_4$?
A) 19 mL
B) 0.33 mL
C) $1.1 \times 10^3$ mL
D) 2.9 mL
E) 6.0 mL

13. You have two solutions of sodium chloride. One is a 2.00 *M* solution, the other is a 4.00 *M* solution. You have much more of the 4.00 *M* solution and you add the solutions together. Which of the following could be the concentration of the final solution?
A) 2.70 *M*
B) 3.00 *M*
C) 3.50 *M*
D) 6.00 *M*
E) 8.10 *M*

14. For the reaction $4FeCl_2(aq) + 3O_2(g) \rightarrow 2Fe_2O_3(s) + 4Cl_2(g)$, what volume of a 0.760 *M* solution of $FeCl_2$ is required to react completely with $6.36 \times 10^{21}$ molecules of $O_2$?
A) $5.26 \times 10^3$ mL
B) 10.7 mL
C) 10.4 mL
D) 18.5 mL
E) 6.02 mL

15. Phosphoric acid, $H_3PO_4$, is a triprotic acid. How many moles of NaOH are needed to neutralize 1.50 L of 0.350 *M* $H_3PO_4$?
A) 1.05 mole
B) 3.00 moles
C) 0.117 mole
D) 0.175 mole
E) 1.58 moles

16. The following reactions

$$ZnBr_2(aq) + 2AgNO_3(aq) \rightarrow Zn(NO_3)_2(aq) + 2AgBr(s)$$
$$KBr(aq) + AgNO_3(aq) \rightarrow AgBr(s) + KNO_3(aq)$$

are examples of
A) oxidation-reduction reactions
B) acid-base reactions
C) precipitation reactions
D) A and C
E) none of these

17. All of the following reactions

$$2Al(s) + 3Br_2(l) \rightarrow 2AlBr_3(s)$$
$$2Ag_2O(s) \rightarrow 4Ag(s) + O_2(g)$$
$$CH_4(l) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$$

can be classified as
A) oxidation-reduction reactions
B) combustion reactions
C) precipitation reactions
D) A and B
E) A and C

18. You have exposed electrodes of a light bulb in a solution of $H_2SO_4$ such that the light bulb is on. You add a dilute solution and the bulb grows dim. Which of the following could be in the solution?
   A) $Ba(OH)_2$
   B) $NaNO_3$
   C) $K_2SO_4$
   D) $Cu(NO_3)_2$
   E) none of these

19. Aqueous solutions of sodium sulfide and copper(II) chloride are mixed together. Which statement is correct?
   A) Both NaCl and CuS precipitate from solution.
   B) No reaction will occur.
   C) CuS will precipitate from solution.
   D) NaCl will precipitate from solution.
   E) A gas is released.

20. When $NH_3(aq)$ is added to $Cu^{2+}(aq)$, a precipitate initially forms. Its formula is:
   A) $Cu(NH)_3$
   B) $Cu(NO_3)_2$
   C) $Cu(OH)_2$
   D) $Cu(NH_3)_2^{2+}$
   E) CuO

21. Which of the following compounds is soluble in water?
   A) $Ni(OH)_2$
   B) $K_3PO_4$
   C) $BaSO_4$
   D) $CoCO_3$
   E) $PbCl_2$

22. Which pair of ions would *not* be expected to form a precipitate when dilute solutions of each are mixed?
A) $Al^{3+}$, $S^{2-}$
B) $Pb^{2+}$, $Cl^{-}$
C) $Ba^{2+}$, $PO_4^{3-}$
D) $Pb^{2+}$, $OH^{-}$
E) $Mg^{2+}$, $SO_4^{2-}$

23. In writing the complete ionic equation for the reaction (if any) that occurs when aqueous solutions of KOH and $Mg(NO_3)_2$ are mixed, which of the following would *not* be written as separate ions?
A) KOH
B) $Mg(NO_3)_2$
C) $Mg(OH)_2$
D) $KNO_3$
E) All of the above would be written as separate ions..

24. When solutions of strontium chloride and sodium sulfate react, which of the following is a spectator ion?
A) strontium ion
B) chloride ion
C) sodium ion
D) sulfate ion
E) two of these

25. Consider the reaction between 15.0 mL of a 1.00 *M* aqueous solution of $AgNO_3$ and 10.0 mL of a 1.00 *M* aqueous solution of $K_2CrO_4$. When these react, a precipitate is observed. What is present in solution **after** the reaction is complete? Note: the solid is not considered to be in solution.
A) $Ag^+$, $NO_3^-$, $K^+$, $CrO_4^{2-}$, water
B) $Ag^+$, $NO_3^-$, $K^+$, water
C) $K^+$, $CrO_4^{2-}$, water
D) $NO_3^-$, $K^+$, $CrO_4^{2-}$, water
E) water

26. A mixture contained no fluorine compound except methyl fluoroacetate, $FCH_2COOCH_3$ (molar mass = 92.07 g/mol). When chemically treated, all the fluorine was converted to $CaF_2$ (molar mass = 78.08 g/mol). The mass of $CaF_2$ obtained was 35.8 g. Find the mass of methyl fluoroacetate in the original mixture.
A) 60.7 g
B) 84.4 g
C) 30.4 g
D) 42.2 g
E) 21.1 g

27. A 1.59-g sample of a metal chloride, $MCl_2$, is dissolved in water and treated with excess aqueous silver nitrate. The silver chloride that formed weighed 3.60 g. Calculate the molar mass of M.
A) 70.9 g/mol
B) 28 g/mol
C) 55.9 g/mol
D) 63 g/mol
E) 72.4 g/mol

28. You mix 55 mL of 1.00 *M* silver nitrate with 25 mL of 0.84 *M* sodium chloride. What mass of silver chloride should you form?
A) 3.0 g
B) 6.0 g
C) 3.3 g
D) 6.6
E) none of these

29. An unknown diprotic acid requires 44.39 mL of 0.111 *M* NaOH to completely neutralize a 0.580-g sample. Calculate the approximate molar mass of the acid.
A) 406 g/mol
B) 235 g/mol
C) 118 g/mol
D) 59 g/mol
E) 203 g/mol

30. What mass of NaOH is required to react exactly with 25.0 mL of 2.7 *M* $H_2SO_4$?
A) 2.7 g
B) 0.7 g
C) 5.4 g
D) 135 g
E) none of these

31. Sulfamic acid, $HSO_3NH_2$ (molar mass = 97.1 g/mol), is a strong monoprotic acid that can be used to standardize a strong base:

$$HSO_3NH_2(aq) + KOH(aq) \rightarrow KSO_3NH_2(aq) + H_2O(l)$$

A 0.165-g sample of $HSO_3NH_2$ required 19.4 mL of an aqueous solution of KOH for a complete reaction. What is the molarity of the KOH solution?
A) 0.00170 *M*
B) 8.76 *M*
C) 0.0876 *M*
D) 0.0330 *M*
E) none of these

32. In which of the following does nitrogen have an oxidation state of +4?
A) $HNO_3$
B) $NO_2$
C) $N_2O$
D) $NH_4Cl$
E) $NaNO_2$

33. The oxidation state of iodine in $IO_3^-$ is:
A) 0
B) +3
C) –3
D) +5
E) –5

34. The oxidation state of carbon in $C_2O_4^{2-}$ is:
   A) 0
   B) +3
   C) –3
   D) +5
   E) –5

35. In the reaction $2Ca(s) + O_2(g) \rightarrow 2CaO(s)$, which species is oxidized?
   A) $O_2$
   B) $O^{2-}$
   C) Ca
   D) $Ca^{2+}$
   E) none of these

36. In the reaction $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$, $N_2$ is
   A) oxidized
   B) reduced
   C) the electron donor
   D) the reducing agent
   E) two of these

37. Which of the following reactions does *not* involve oxidation-reduction?
   A) $CH_4 + 3O_2 \rightarrow 2H_2O + CO_2$
   B) $Zn + 2HCl \rightarrow ZnCl_2 + H_2$
   C) $2Na + 2H_2O \rightarrow 2NaOH + H_2$
   D) $MnO_2 + 4HCl \rightarrow Cl_2 + 2H_2O + MnCl_2$
   E) All are oxidation-reduction reactions.

38. Which of the following statements is(are) *true*? Oxidation and reduction
   A) cannot occur independently of each other
   B) accompany all chemical changes
   C) describe the loss and gain of electron(s), respectively
   D) result in a change in the oxidation states of the species involved
   E) A, C, and D

39. In the reaction $Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$, which, if any, element is oxidized?
   A) zinc
   B) hydrogen
   C) sulfur
   D) oxygen
   E) none of these

40. In the following reaction, which species is the reducing agent?
   $8NaI + 5H_2SO_4 \rightarrow 4I_2 + H_2S + 4Na_2SO_4 + 4H_2O$
   A) $H_2SO_4$
   B) $NaI$
   C) $I_2$
   D) $H_2S$
   E) $Na_2SO_4$

41. In which of the following does sulfur have the oxidation state of +2?
   A) $SO_2$
   B) $S_2O_3^{2-}$
   C) $H_2S$
   D) $SF_2$
   E) None of the above

42. In which of the following does iodine have the lowest oxidation state?
A) $LiIO_3$
B) $IO_2$
C) $I_2O$
D) $NH_4I$
E) $I_2$

43. Which of the following substances can form an aqueous solution that conducts electricity well enough to allow a light bulb to shine brightly?
A) Sugar
B) Ammonium nitrate
C) Oxygen gas
D) Alcohol
E) None of the above

44. 910 mL of 0.184 *M* $Pb(ClO_4)_2$ with 288 mL of 0.905 *M* $K_3PO_4$ are combined. What is the molarity of $Pb^{2+}$ in the combined solution **after the reaction**. (Assume that the volumes of the solutions are simply added to result in the final volume.)

A) 0.509 *M*
B) 0.146 *M*
C) 0.00 *M*
D) 0.342 *M*
E) 0.779 *M*

45. We mix 897 mL of 0.247 *M* $AgClO_3$ with 577 mL of 0.226 *M* $NH_4OH$. What is the molarity of $Ag^+$ in the combined solution **after the reaction**. (Assume that the volumes of the solutions are simply added to result in the final volume.)
A) 0.642 *M*
B) 0.016 *M*
C) 0.912 *M*
D) 0.759 *M*
E) 0.062 *M*

46. What is the complete ionic equation for the reaction that occurs if we mix aqueous solutions of $Pb(NO_3)_2$ and $AlBr_3$?

A) $3Pb^{2+}(aq) + 6\ NO_3^{-}(aq) + 2Al^{3+}(aq) + 6Br^{-}(aq) \rightarrow 3PbBr_2(s) + 2Al^{3+}(aq) + 6NO_3^{-}(aq)$

B) $3Pb^{2+}(aq) + 6Br^{-}(aq) \rightarrow 3Pb^{2+}(s) + 6Br^{-}(s)$

C) $3Pb(NO_3)_2(aq) + 2AlBr_3(aq) \rightarrow 3PbBr_2(s) + 2Al(NO_3)_3(aq)$

D) $3Pb^{2+}(aq)+6NO_3^{-}(aq)+2Al^{3+}(aq)+2Br^{-}(aq)\rightarrow 3Pb^{2+}(s)+2Br^{-}(s)+2Al^{3+}(aq)+2NO_3^{-}(aq)$

E) $3Pb^{2+}(aq) + 6Br^{-}(aq) \rightarrow 3PbBr_2(s)$

# Ch. 4 practice questions (updated on 2020-10-08)
## Answer Section

1. C
2. D
3. E

| | |
|---|---|
| $XOF$ | $X + (-2) + (-1) = 0$ ==> X=3 |
| $X_2O_2Cl_4$ | $2X + 2(-2) + 4(-1) = 0$ ==> X=4 |
| $X_2O_2F^{2+}$ | $2X + 2(-2) + (-1) = 2$ ==> X=3.5 |
| $XO_2Cl_3^{2-}$ | $X + 2(-2) + 3(-1) = -2$ ==> X=5 |
| $X_2OI^-$ | $2X + (-2) + (-1) = -1$ ==> X=1 lowest |

4. A

Molecular equation:
$Zn(ClO_4)_2(aq) + 2\ KOH(aq) \rightarrow Zn(OH)_2(s) + 2\ KClO_4(aq)$

Complete ionic equation:
$Zn^{2+}_{(aq)} + 2ClO_4^-{}_{(aq)} + 2K^+_{(aq)} + 2OH^-_{(aq)} \rightarrow Zn(OH)_{2(s)} + 2K^+_{(aq)} + 2ClO_4^-(aq)$

Net ionic equation:
$Zn^{2+}_{(aq)} + 2OH^-_{(aq)} \rightarrow Zn(OH)_{2(s)}$

5. C

Molecular equation:
$AgNO_3(aq) + CsOH(aq) \rightarrow AgOH(s) + CsNO_3(aq)$

Complete ionic equation:
$Ag^+_{(aq)} + NO_3^-{}_{(aq)} + Cs^+_{(aq)} + OH^-_{(aq)} \rightarrow AgOH_{(s)} + Cs^+_{(aq)} + NO_3^-(aq)$

Net ionic equation:
$Ag^+_{(aq)} + OH^-_{(aq)} \rightarrow AgOH_{(s)}$

6. E

   Molecular equation:
   $3\ AgNO_3(aq) + Rb_3PO_4(aq) \rightarrow Ag_3PO_4(s) + 3\ RbNO_3(aq)$

   Complete ionic equation:
   $3Ag^+(aq) + 3NO_3^-(aq) + 3Rb^+(aq) + PO_4^{3-}(aq) \rightarrow Ag_3PO_4(s) + 3Rb^+(aq) + 3NO_3^-(aq)$

   Net ionic equation:
   $3Ag^+(aq) + PO_4^{3-}(aq) \rightarrow Ag_3PO_{4(s)}$
7. C
8. C
9. B
10. B
11. A
12. A
13. C
14. D
15. E
16. C
17. A
18. A
19. C
20. C
21. B
22. E
23. C
24. E
25. D
26. B
27. C
28. A
29. B
30. C
31. C
32. B
33. D
34. B
35. C
36. B
37. E

38. E
39. A
40. B
41. D
42. D
43. B
44. C

Balanced reaction equation:

$3\ Pb(ClO_4)_2 + 2\ K_3PO_4 \rightarrow\ Pb_3(PO_4)_2 + 6\ KClO_4$

moles of $Pb(ClO_4)_2$ = M · V = $(0.184\ \frac{\text{mol}}{\text{L}})\ (910\ \text{mL} \times \frac{10^{-3}\ \text{L}}{1\ \text{mL}}) = 0.16744$ mol

moles of $K_3PO_4$ = M · V = $(0.905\ \frac{\text{mol}}{\text{L}})\ (288\ \text{mL} \times \frac{10^{-3}\ \text{L}}{1\ \text{mL}}) = 0.26064$ mol

moles of $Pb^{2+}$ brought in initially = $0.16744\,\text{mol}\,Pb(ClO_4)_2 \times \frac{1\ \text{mol}\,Pb}{1\ \text{mol}\,Pb(ClO_4)_2} = 0.16744\,\text{mol}$

Finding limiting reactant:

$Pb(ClO_4)_2$:

moles/coefficient = 0.16744 / 3 = 0.0558 Limiting

$K_3PO_4$

moles/coefficient = 0.26064 / 2 = 0.130 Not limiting

If the cation we are asked about were not limiting, we would have calculated the amount of it consumed by the limiting reactant:

moles of $Pb^{2+}$ consumed =

$$0.26064\,\text{mol}\,K_3PO_4 \times \frac{3\,\text{mol}\,Pb(ClO_4)_2}{2\,\text{mol}\,K_3PO_4} \times \frac{1\ \text{mol}\,Pb}{1\,\text{mol}\,Pb(ClO_4)_2}$$

and would have subtracted it from its initial amount.

But it is part of the limiting reactant, and is the part of the reactant that actually gets removed from solution by precipitating with the anion of the other reactant. It is completely consumed:

moles of $Pb^{2+}$ remaining = 0.00 mol

Molarity of $Pb^{2+}$ remaining = $\frac{0.00\,\text{mol}}{1.198\,\text{L}} =\ 0.00\ M$

45. E

Balanced reaction equation:

$AgClO_3(aq) + NH_4OH(aq) \rightarrow AgOH(s) + NH_4ClO_3(aq)$

moles of $AgClO_3 = M \cdot V = (0.247\ \frac{mol}{L})\ (897\ mL \times \frac{10^{-3}\ L}{1\ mL}) = 0.22\underline{1}6$ mol

moles of $NH_4OH = M \cdot V = (0.226\ \frac{mol}{L})\ (577\ mL \times \frac{10^{-3}\ L}{1\ mL}) = 0.13\underline{0}4$ mol

moles of $Ag^+$ brought in initially $= 0.22\underline{1}6\ mol\ AgClO_3 \times \frac{1\ mol\ Ag^+}{1\ mol\ AgClO_3} = 0.22\underline{1}6$ mol

Finding limiting reactant:

$AgClO_3$:

moles/coefficient = $0.22\underline{1}6 / 1 = 0.22\underline{1}6$ Excess

$NH_4OH$:

moles/coefficient = $0.13\underline{0}4 / 1 = 0.13\underline{0}4$ Smaller ==> Limiting

We calculate the amount of the cation consumed by the limiting reactant:

$$\text{moles of } Ag^+ \text{ consumed} = 0.13\underline{0}4\, mol\, NH4OH \times \frac{1\ mol\ AgClO_3}{1\ mol\ NH4OH} \times \frac{1\ mol\ Ag^+}{1\ mol\ AgClO_3} = 0.130\ mol$$

and subtract it from its initial amount:

moles of $Ag^+$ remaining $= 0.22\underline{1}6 - 0.13\underline{0}4 = 0.09\underline{1}2$ mol

$$\text{Molarity of } Ag^+ \text{ remaining} = \frac{0.09\underline{1}2\, mol}{(897 + 577) \times 10^{-3}\ L} = 0.062\ M$$

46. A

Molecular equation:

$3\ Pb(NO_3)_2(aq) + 2\ AlBr_3(aq) \rightarrow 3\ PbBr_2(s) + 2\ Al(NO_3)_3(aq)$

Complete ionic equation:

$3Pb^{2+}{}_{(aq)} + 6NO_3^-{}_{(aq)} + 2Al^{3+}{}_{(aq)} + 2Br^-{}_{(aq)} \rightarrow 3PbBr_{2(s)} + 2Al^{3+}{}_{(aq)} + 2NO_3^-(aq)$

Net ionic equation:

$3Pb^{2+}{}_{(aq)} + 2Br^-{}_{(aq)} \rightarrow 3PbBr_{2(s)}$

# Additional solutions to questions

(9) I. We only see $H^+$ and $X^-$, the dissociated form of an acid, HX.
We see no undissociated HX molecules.
This implies a strong acid.

II. In addition to $H^+$ and $X^-$, we see undissociated HX molecules
This implies a weak acid

(10) $M = \frac{\text{moles}}{\text{liters}}$

moles of $SrCl_2 = 38.1\,g \times \frac{1\text{ mol}}{158.53\,g} = 0.2403\text{ mol}$

$M = \frac{0.2403\text{ mol}}{112.5 \times 10^{-3}\,L} = 2.14\,M$

(11) First we calculate the molarity of the solution we will dilute.

moles of $Ba(OH)_2 = 74.28\,g \times \frac{1\text{ mol}}{171.34\,g} = 0.43352\text{ mol}$

$M_1 = \frac{0.43352\text{ mol}}{2.450\,L} = 0.17695\,M$

We are asked the volume of this solution needed to make 1.000 L of 0.100 M $Ba(OH)_2$ by dilution

$M_1V_1 = M_2V_2 \Longrightarrow V_1 = \frac{M_2V_2}{M_2}$

$V_1 = \frac{(0.100)(1.000)}{0.17695} = 0.565\,L \times \frac{1\,mL}{10^{-3}\,L} = 565\,mL$

(12) It's a dilution problem:

$$M_1V_1 = M_2V_2 \implies V_1 = \frac{M_2V_2}{M}$$

$$V_1 = \frac{(0.145M)\ (2.30L)}{18M} = 0.019\,L \times \frac{1\,mL}{10^{-3}\,L} = 19\,mL$$

(13) If we used equal volumes of 2M and 4M solutions, the final molarity would be the average of the two molarities: 3M

If we have much more of the 4M solution, the final molarity should be closer to 4M, but it cannot exceed 4M

3.50M is the only choice that fits

(14) We convert number of molecules of $O_2$ to moles of $O_2$

Relate it to the number of moles of $FeCl_2$ using the reaction stoichiometry

Then calculate the volume using the molarity of $FeCl_2$

$$6.36 \times 10^{21} \text{ molecules of } O_2 \times \frac{1 \text{ mol } O_2}{6.022 \times 10^{23} \text{ molec. of } O_2} = 0.01056 \text{ mol } O_2$$

$$0.01056 \text{ mol } O_2 \times \frac{4 \text{ mol } FeCl_2}{3 \text{ mol } O_2} = 0.01408 \text{ mol } FeCl_2$$

$$n = M \cdot V$$

$$0.01408 \text{ mol} = \left(0.760 \frac{\text{mol}}{L}\right) V$$

$$\implies V = 0.0185\,L \times \frac{1\,mL}{10^{-3}\,L} = 18.5\,mL$$

(15) $H_3PO_4(aq) + 3NaOH \rightarrow Na_3PO_4(aq) + 3H_2O$

$$n_{H_3PO_4} = M_{H_3PO_4} \times V_{H_3PO_4} = \left(0.350\,\frac{mol}{L}\right)(1.50\,L) = 0.525 \text{ mol } H_3PO_4$$

$$n_{NaOH} = 0.525 \text{ mol } H_3PO_4 \times \frac{3 \text{ mol } NaOH}{1 \text{ mol } H_3PO_4} = 1.58 \text{ mol } NaOH$$

(16) You should be able to recognize these reactions as precipitation reactions

$$ZnBr_2(aq) + 2AgNO_3(aq) \rightarrow Zn(NO_3)_2(aq) + 2AgBr(s)$$

$Zn^{2+}$ $\boxed{Br^- \qquad Ag^+}$ $NO_3^-$

insoluble combination

$$KBr(aq) + AgNO_3(aq) \rightarrow AgBr(s) + KNO_3(aq)$$

$K^+$ $\boxed{Br^- \qquad Ag^+}$ $NO_3^-$

insoluble combination

(17) Occurence of free elements in the reactions or the burning of a fuel with oxygen point to redox reactions. You can confirm this by assignin oxidation states and observe changes in them.

(18) Bulb growing dim implies the removal of electrolytes.

$$H_2SO_4(aq) + Ba(OH)_2(aq) \longrightarrow BaSO_4(s) + 2H_2O(\ell)$$

$2H^+$ $\boxed{SO_4^{2-} \quad Ba^{2+}}$ $2OH^-$

insoluble combination

combine into $H_2O$, a non-electrolyte

None of the others remove $SO_4^{2-}$ or $H^+$

(19) $Na_2S$ $\quad$ $CuCl_2$

$Na^+$ $\boxed{S^{2-} \quad Cu^{2+}}$ $Cl^-$

insoluble combination

CuS will precipitate

(20) $NH_3$ is a weak base.

It produces $OH^-$ in aqueous solution

$$NH_3(aq) + H_2O(\ell) \longrightarrow NH_4^+(aq) + OH^-(aq)$$

$$OH^-(aq) + Cu^{2+}(aq) \longrightarrow Cu(OH)_2(s)$$

(21) Any salt where the cation is $K^+$ would be soluble.

$K_3PO_4$ is soluble.

Others are insoluble according to the solubility rules

(22) $MgSO_4$ is soluble, and the other choices are not according to the solubility rules

(23) Only the precipitate is not written in the complete ionic equation.

$$KOH \qquad Mg(NO_3)_2$$

$$K^+ \quad \boxed{OH^- \quad Mg^{2+}} \quad NO_3^-$$

insoluble combination $\Longrightarrow$ $Mg(OH)_2(s)$ is the precipitate and would be written as a chemical formula, and not as separate ions

$$2K^+(aq) + 2OH^-(aq) + Mg^{2+}(aq) + 2NO_3^-(aq) \rightarrow Mg(OH)_2(s) + 2K^+(aq) + 2NO_3^-(aq)$$

(24) The ions that are not precipitating would be the spectator ions.

$Sr^{2+}$ & $SO_4^{2-}$ would precipitate as $SrSO_4(s)$

$Cl^-$ and $Na^+$ would be spectator ions

(25) In addition to water and the spectator ions, the ions of the excess reactant would be present.

$$2AgNO_3(aq) + K_2CrO_4(aq) \rightarrow Ag_2CrO_4(s) + 2KNO_3(aq)$$

$$n_{AgNO_3} = \left(1.00\,\frac{mol}{L}\right)(15.0\times10^{-3}\,L) = 0.0150\,mol \xrightarrow{\div 2} 0.00750 \text{ smaller, } \Rightarrow \text{limiting}$$

$$n_{K_2CrO_4} = \left(1.00\,\frac{mol}{L}\right)(10.0\times10^{-3}\,L) = 0.0100\,mol \xrightarrow{\div 1} 0.0100 \text{ larger excess}$$

So, in addition to water and the spectator (non-precipitating) ions $K^+$ and $NO_3^-$, $CrO_4^{2-}$ would be present after rxn.

(26) All the fluorine in $FCH_2COOCH_3$ ends up in 35.8g $CaF_2$
We can work back to the amount of $FCH_2COOCH_3$ from the amount of $CaF_2$

$$35.8g\ CaF_2 \times \frac{1\ mol\ CaF_2}{78.08g\ CaF_2} \times \frac{2\ mol\ F}{1\ mol\ CaF_2} \times \frac{1\ mol\ FCH_2COOCH_3}{1\ mol\ F} \times \frac{92.07g\ FCH_2COOCH_3}{1\ mol\ FCH_2COOCH_3}$$

$$= 84.4\ g\ FCH_2COOCH_3$$

(27) All the $Cl^-$ in $MCl_2$ ends up in AgCl.
We can work back to the moles of $MCl_2$ from the amount of AgCl, which would allow us to calculate the molar mass of $MCl_2$. Then we can calculate the molar mass of M, since we know the molar mass of Cl

$$3.60g\ AgCl \times \frac{1\ mol\ AgCl}{143.32g\ AgCl} \times \frac{1\ mol\ Cl^-}{1\ mol\ AgCl} \times \frac{1\ mol\ MCl_2}{2\ mol\ Cl^-} = 0.01256\ mol\ MCl_2$$

$$\text{molar mass of } MCl_2 = \frac{1.59\ g}{0.01256\ mol} = 126.6\ g/mol$$

$$M + (2)(35.45) = 126.6$$

$$M = 126.6 - (2)(35.45) = 56\ g/mol$$

(28) $AgNO_3(aq) + NaCl(aq) \longrightarrow AgCl(s) + NaNO_3(aq)$

M and V are given for both reactants, which give the number of moles for each.

We need to calculate the mass of AgCl (s) based on the limiting reactant.

coeff. in rxn. eqn.

$$n_{AgNO_3} = M \cdot V = \left(1.00 \frac{mol}{L}\right)(55 \times 10^{-3} L) = 0.055 \text{ mol} \xrightarrow{\div 1} 0.055$$

$$n_{NaCl} = M \cdot V = \left(0.84 \frac{mol}{L}\right)(25 \times 10^{-3} L) = 0.021 \text{ mol} \xrightarrow{\div 1} 0.021$$

limiting

$$0.021 \text{ mol NaCl} \times \frac{1 \text{ mol AgCl}}{1 \text{ mol NaCl}} \times \frac{143.32 \text{ g AgCl}}{1 \text{ mol AgCl}} = 3.0 \text{ g AgCl}$$

(29) A diprotic acid can be written as $H_2A$

$$H_2A + 2NaOH \longrightarrow Na_2A + 2H_2O$$

Each mol of a diprotic acid needs 2 mol of NaOH to be neutralized.

$$n_{NaOH} = M \cdot V = \left(0.111 \frac{mol}{L}\right)(44.39 \times 10^{-3} L) = 0.004927 \text{ mol NaOH}$$

$$n_{H_2A} = 0.004927 \text{ mol NaOH} \times \frac{1 \text{ mol } H_2A}{2 \text{ mol NaOH}} = 0.002464 \text{ mol } H_2A$$

$$\text{molar mass of } H_2A = \frac{0.580 \text{ g}}{0.002464 \text{ mol}} = 235 \text{ g/mol}$$

30) This time let's use the molarity as a conversion factor to go from the volume of $H_2SO_4$ to moles of $H_2SO_4$ and then proceed to relate it to the amount of NaOH required using the rxn stoichiometry

$$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$$

$$25.0 \times 10^{-3}\,L\,H_2SO_4 \times \frac{2.7\,mol\,H_2SO_4}{1\,L\,H_2SO_4} \times \frac{2\,mol\,NaOH}{1\,mol\,H_2SO_4} \times \frac{40.00\,g\,NaOH}{1\,mol\,NaOH} = 5.4\,g\,NaOH$$

31) $$\text{moles of KOH} = 0.165\,g\,HSO_3NH_2 \times \frac{1\,mol\,HSO_3NH_2}{97.1\,g\,HSO_3NH_2} \times \frac{1\,mol\,KOH}{1\,mol\,HSO_3NH_2}$$

$$= 0.001699\,mol$$

$$M_{KOH} = \frac{0.001699\,mol}{19.4 \times 10^{-3}\,L} = 0.0876\,M$$

32) $\overset{+1}{H}\overset{x}{N}\overset{-2}{O_3}$ $\quad 1 + x + (3)(-2) = 0 \Rightarrow x = +5$

$$\boxed{\overset{x}{N}\overset{-2}{O_2} \quad x + (2)(-2) = 0 \Rightarrow x = +4}$$

$\overset{x}{N_2}\overset{-2}{O}$ $\quad 2x + (-2) = 0 \Rightarrow x = +1$

$NH_4Cl \Rightarrow \overset{x\ +1}{NH_4^+} \quad Cl^-$

$\Rightarrow x + (4)(+1) = +1 \Rightarrow x = -3$

$NaNO_2 \rightarrow Na^+ \quad \overset{x\ -2}{NO_2^-} \Rightarrow x + (2)(-2) = -1 \Rightarrow x = +3$

33) $\overset{x}{I}\overset{-2}{O}_3^{-} \implies x + (3)(-2) = -1 \implies x = +5$

34) $\overset{x}{C}_2\overset{-2}{O}_4^{2-} \implies 2x + (4)(-2) = -2 \implies x = +3$

35)

oxidized

$$2\overset{0}{Ca}(s) + \overset{0}{O}_2(g) \rightarrow 2\overset{+2}{Ca}\overset{-2}{O}(s)$$

reduced

36)

$$\overset{0}{N}_2(g) + 3\overset{0}{H}_2(g) \rightarrow 2\overset{-3}{N}\overset{+1}{H}_3(g)$$

reduced

37) We see that three of the reactions involve free elements (and are not one of the two exceptions) and therefore are redox reactions.

Let's check the fourth rxn:

reduced

$$\overset{+4}{Mn}\overset{-2}{O}_2 + 4\overset{+1}{H}\overset{-1}{Cl} \rightarrow \overset{0}{Cl}_2 + 2\overset{+1}{H}_2\overset{-2}{O} + \overset{+2}{Mn}\overset{-1}{Cl}_2$$

oxidized

It is also a redox rxn.

So, all are oxidation-reduction reactions

39)

oxidized

$$\overset{0}{Zn} + \overset{+1}{H}_2SO_4 \rightarrow \overset{+2}{Zn}SO_4 + \overset{0}{H}_2$$

(40)

$$\overset{+1\;-1}{8NaI} + \overset{+1\;+6\;-2}{5H_2SO_4} \longrightarrow 4\overset{0}{I_2} + \overset{+1\;-2}{H_2S} + 4\overset{+1\;+6\;-2}{Na_2SO_4} + 4\overset{+1\;-2}{H_2O}$$

oxidized

The wording of the question is imperfect, as "species" normally refers to compounds or ions. But the answer choices imply that we are asked which element is oxidized.

Iodine (I) is oxidized.

(41)

$\overset{x\;-2}{SO_2}$ $\quad x + (2)(-2) = 0 \Rightarrow x = +4$

$\overset{x\;-2}{S_2O_3}$ $\quad 2x + (3)(-2) = 0 \Rightarrow x = +3$

$\overset{+1\;x}{H_2S}$ $\quad (2)(+1) + x = 0 \Rightarrow x = -2$

$\overset{x\;-1}{SF_2}$ $\quad x + (2)(-1) = 0 \Rightarrow x = +2$

(42)

$LiIO_3 \Rightarrow Li^+\ \overset{x\;-2}{IO_3^-} \Rightarrow x + (3)(-2) = -1 \Rightarrow x = +5$

$\overset{x\;-2}{IO_2} \Rightarrow x + (2)(-2) = 0 \Rightarrow x = +4$

$\overset{x\;-2}{I_2O} \Rightarrow 2x + (-2) = 0 \Rightarrow x = +1$

$NH_4I \Rightarrow NH_4^+\ \overset{-1}{I^-}$ lowest

$\overset{0}{I_2}$

(43) Ammonium nitrate, $NH_4NO_3$, is an ionic compound of $NH_4^+$ and $NO_3^-$ ions.

It dissolves in water as separate ions, and therefore its aqueous solutions conduct electricity, allowing electric current to pass and light up an electric light bulb.