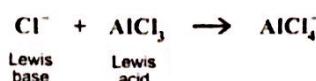


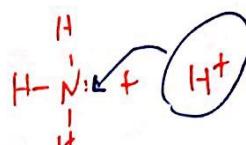
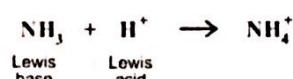
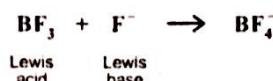
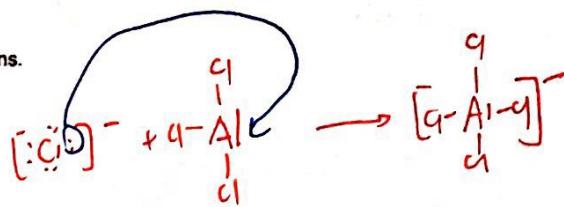
## Focus 6 (1) 整理 Acid and Base

4.

Identify the Lewis acid and Lewis base in each of the following reactions.



Lewis  
base  
Lewis  
acid



14.

An unknown mass of  $\text{Na}_2\text{O}$  (molar mass = 61.979 g/mol) was dissolved in enough water to create a 200.0 mL stock solution. A 5.00 mL sample of the stock solution was transferred to a volumetric flask and diluted to 500.0 mL. The pH of the dilute solution is 13.09.

Calculate the concentration of  $\text{OH}^-$  ions in the dilute solution.

Number	
0.123	M

Next, calculate the concentration of  $\text{OH}^-$  ions in the stock solution.

Number	
12.3	M

$1\text{mL} \rightarrow 500\text{mL}$ , 稀释  $100^{1/4}$

Finally, determine the original mass of  $\text{Na}_2\text{O}$  dissolved in the stock solution.

Number	
76	g

$$12.3 \times 0.2 \div 2 \times 62 = 76.269$$



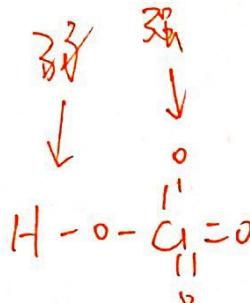
19.

Rank the oxoacids of chlorine according to strength.

Strongest acid



Weakest acid



同元素: O↑, 酸↑

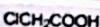
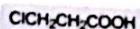
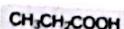
同价: 电负性↑, 键强, 不断, 酸↓



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20.

Rank these acids according to their expected  $pK_a$  values.

Highest  $pK_a$ Lowest  $pK_a$ 

短，电负性↑

- 酸：电负性弱  $pK_a \uparrow$

有O/氯原子：电负性强  $pK_a \uparrow$

21.

Choose the phrases that best complete the statements regarding the relative acid strength of these acids.

HIO is less acidic than HClO because

- the electronegativities of I and Cl are the same.
- I is the more electronegative central atom.
- Cl is the more electronegative central atom.

有O，电负性↑， $\checkmark$  极性↑，  
酸性↑

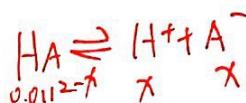
HBrO<sub>3</sub> is more acidic than HBrO because

- the acids have the same central atom, the bonds to the central atom are of similar polarity and strength.
- HBrO has less oxygen atoms, which creates more polar and stronger bonds to the central atom.
- HBrO<sub>3</sub> has more oxygen atoms, which creates more polar and stronger bonds to the central atom.

24.

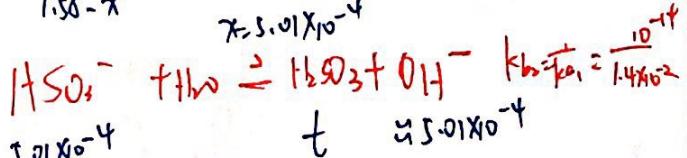
If enough of a monoprotic acid is dissolved in water to produce a 0.0112 M solution with a pH of 6.40, what is the equilibrium constant,  $K_a$ , for the acid?

$$K_a = \frac{\text{Number}}{0.0112 - x} = 1.33 \times 10^{-11}$$



$$10^{-6.4} - x = 10^{-7.6}$$

$$K_a = \frac{x \cdot x}{0.0112 - x} = \frac{10^{-6.4} \cdot x}{0.0112 - x}$$



$$[\text{H}_2\text{SO}_3] \approx K_b$$

32.

Calculate the concentrations of all species in a 1.58 M Na<sub>2</sub>SO<sub>3</sub> (sodium sulfite) solution. The ionization constants for sulfurous acid are  $K_{a1} = 1.4 \times 10^{-2}$  and  $K_{a2} = 6.3 \times 10^{-8}$ .

$$[\text{Na}^+] = \frac{\text{Number}}{M} = 3.16 \text{ M}$$

$$[\text{SO}_3^{2-}] = \frac{\text{Number}}{M} = 1.58 \text{ M}$$

$$[\text{HSO}_3^-] = \frac{\text{Number}}{M} = 5.01 \times 10^{-4} \text{ M}$$

$$[\text{H}_2\text{SO}_3] = \frac{\text{Number}}{M} = 7.14 \times 10^{-13} \text{ M}$$

$$[\text{OH}^-] = \frac{\text{Number}}{M} = 5.01 \times 10^{-4} \text{ M}$$

$$[\text{H}^+] = \frac{\text{Number}}{M} = 2.00 \times 10^{-11} \text{ M}$$



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36.

Phosphoric acid,  $H_3PO_4$ (aq), is a triprotic acid, meaning that one molecule of the acid has three acidic protons. Estimate the pH and the concentrations of all species in a 0.450 M phosphoric acid solution.

	$pK_{a1}$	$pK_{a2}$	$pK_{a3}$
	2.16	7.21	12.32

$$[H_3PO_4] = \boxed{0.398} \text{ M}$$

$$[H_2PO_4^-] = \boxed{0.0524} \text{ M}$$

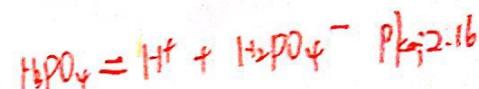
$$[HPO_4^{2-}] = \boxed{6.17 \times 10^{-3}} \text{ M}$$

$$[PO_4^{3-}] = \boxed{5.64 \times 10^{-10}} \text{ M}$$

$$[H^+] = \boxed{0.0524} \text{ M}$$

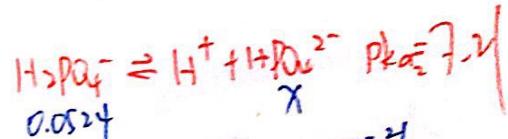
$$[OH^-] = \boxed{1.91 \times 10^{-13}} \text{ M}$$

$$pH = \boxed{1.28}$$



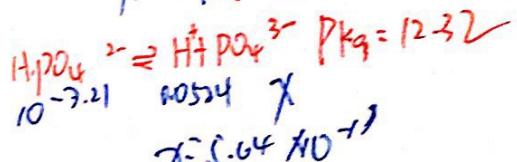
$$0.45 \cancel{A} \quad \cancel{X} \quad \cancel{X}$$

$$\cancel{X} = 0.0524$$



$$0.0524 \cancel{X}$$

$$X = K_{a2} = 10^{-7.21}$$



$$10^{-7.21} \quad 0.0524 \cancel{X}$$

$$X = 5.64 \times 10^{-10}$$

37.

A large volume of 0.1590 M  $H_2SO_3$ (aq) is treated with enough NaOH(s) to adjust the pH of the solution to 5.55. Assuming that the addition of NaOH(s) does not significantly affect the volume of the solution, calculate the final molar concentrations of  $H_2SO_3$ (aq),  $HSO_3^-$ (aq), and  $SO_3^{2-}$ (aq) in solution given that the  $K_{a1}$  and  $K_{a2}$  values are  $1.50 \times 10^{-2}$  and  $1.20 \times 10^{-7}$ , respectively.

### 二元酸浓度公式

$$[H_2SO_3] = \boxed{2.86 \times 10^{-5}} \text{ M}$$

$$[HSO_3^-] = \boxed{0.152} \text{ M}$$

$$[SO_3^{2-}] = \boxed{6.49 \times 10^{-3}} \text{ M}$$

$$M = [H_2SO_3] + [HSO_3^-] + [SO_3^{2-}] = 0.159 \text{ M}$$

$$\frac{[H_2SO_3]}{M} = \frac{[H_3O^+]^2}{[H_3O^+]^2 + [HSO_3^-]^2 + [SO_3^{2-}]^2} \times K_{a1} K_{a2} K_C$$

$$\frac{[HSO_3^-]}{M} = \frac{[H_3O^+] K_{a1}}{H}$$

$$\frac{[SO_3^{2-}]}{M} = \frac{[H_3O^+] K_{a2}}{H}$$

45.

Carbon dioxide dissolves in water to form carbonic acid. Estimate the thermodynamic equilibrium constant for this reaction using the  $\Delta G^\circ$  values in the table.

$$K = \boxed{2.000 \times 10^{-3}}$$

$$\Delta G^\circ = -RT \ln K$$

Substance	$\Delta G^\circ$ (kJ/mol)
$H_2CO_3(aq)$	-616.1
$H_2O(l)$	-237.1
$CO_2(g)$	-394.4

Carbonic acid then ionizes in water ( $K_{a1} = 4.5 \times 10^{-7}$ ).

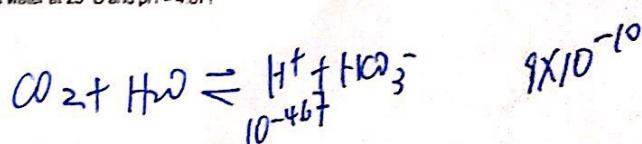
Ignoring  $K_{a2}$ , estimate  $K$  for the overall process by which  $CO_2$  and  $H_2O$  form  $H^+$  and  $CO_3^{2-}$ .

$$K = \boxed{9.000 \times 10^{-10}}$$

$$2 \times 10^{-3} \times 4.5 \times 10^{-7}$$

What is the pressure of  $CO_2$  in equilibrium with carbonated water at 25 °C and pH = 4.67?

$$P_{CO_2} = \boxed{0.49} \text{ atm}$$



$$\frac{(10^{-4.67})^2}{\cancel{X}} = 9 \times 10^{-10}$$

$$\cancel{X} = 0.51 \text{ bar} = 0.51 \text{ atm}$$

bar, M 都是标准单位!



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50.

Calculate the pH of the solution that results from mixing 67.0 mL of 0.057 M HCN(aq) with 33.0 mL of 0.020 M NaCN(aq). The  $K_a$  value for HCN is  $4.9 \times 10^{-10}$ .

pH = Number  
8.55

37.0 mL of 0.031 M HCN(aq) with 63.0 mL of 0.070 M NaCN(aq).

pH = Number  
9.89

50.0 mL of 0.111 M HCN(aq) with 50.0 mL of 0.111 M NaCN(aq).

pH = Number  
9.31

这儿

buffer

$$\text{pH} = \text{p}K_a + \log \frac{[\text{base}]_{\text{final}}}{[\text{acid}]_{\text{final}}} \quad \begin{matrix} \uparrow \\ 0.2 \div 100 \times 33 \\ \downarrow \\ 0.2 \div 100 \times 67 \end{matrix}$$

52.

Calculate the change in pH when 9.00 mL of 0.100 M HCl(aq) is added to 100.0 mL of a buffer solution that is 0.100 M in  $\text{NH}_3$ (aq) and 0.100 M in  $\text{NH}_4\text{Cl}$ (aq). A list of ionization constants can be found [here](#).

$\Delta \text{pH} =$  Number  
-0.0785

 $\Delta \text{pH} = \downarrow$ 

$$= \log \frac{0.1 \times 0.1 - 9 \times 10^{-4}}{0.1 \times 0.1 + 9 \times 10^{-4}}$$

Calculate the change in pH when 9.00 mL of 0.100 M NaOH(aq) is added to the original buffer solution.

$\Delta \text{pH} =$  Number  
0.078

同理

54.

Which weak acid would be best to use when preparing a buffer solution with a pH of 9.70?

- An acid with  $K_a = 3.2 \times 10^{-8}$
- An acid with  $K_a = 2.1 \times 10^{-9}$
- An acid with  $K_a = 1.3 \times 10^{-10}$
- An acid with  $K_a = 2.5 \times 10^{-6}$
- An acid with  $K_a = 4.0 \times 10^{-7}$
- An acid with  $K_a = 3.2 \times 10^{-5}$

当  $[\text{HA}] = [\text{H}^+]$  时 最佳

即  $\text{pH} = \text{p}K_a$

57.

Calculate the pH for each of the following cases in the titration of 50.0 mL of 0.190 M  $\text{HClO}$ (aq) with 0.190 M KOH(aq). The ionization constant for  $\text{HClO}$  can be found [here](#).

(a) before addition of any KOH

Number  
4.06

(b) after addition of 25.0 mL of KOH

Number  
7.40

(c) after addition of 35.0 mL of KOH

Number  
7.77

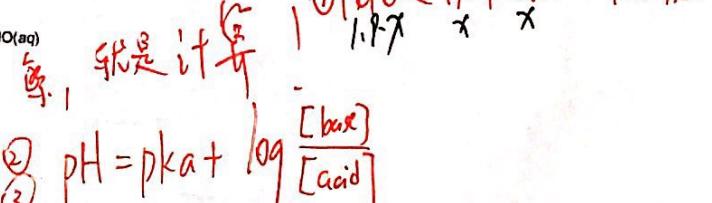
(d) after addition of 50.0 mL of KOH

Number  
10.19

(e) after addition of 60.0 mL of KOH

Number  
12.24

Corre



② 算是计算

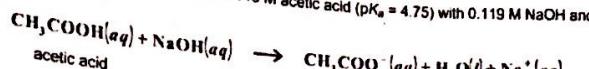
$$\text{③ } \text{pH} = \text{p}K_a + \log \frac{[\text{base}]}{[\text{acid}]}$$



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58.

Consider the titration of 25.0 mL of 0.140 M acetic acid ( $pK_a = 4.75$ ) with 0.119 M NaOH and answer the questions.



- a. Determine the initial pH of 0.140 M acetic acid solution before NaOH is added.

Number
2.80

- b. Determine the pH of the solution after 10.0 mL of 0.119 M NaOH is added.

Number
4.46

- c. Determine the volume of 0.119 M NaOH required to reach halfway to the stoichiometric point of the titration.

Number
14.7

volume NaOH = mL

Scroll down  
There are  
additions  
to this Q.

Correct.

- d. Determine the pH of the solution when enough NaOH has been added to reach halfway to the stoichiometric point.

Number
4.75

- e. Determine the volume of 0.119 M NaOH that is required to reach the stoichiometric point of the reaction.

Number
29.4

volume NaOH = mL

- f. Calculate the pH of the solution when the stoichiometric point of the titration has been reached.

Number
8.78

65.

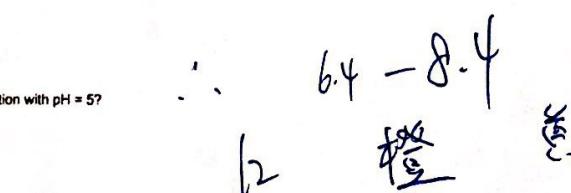
A certain indicator, HA, has a  $K_a$  value of  $4.0 \times 10^{-5}$ . The protonated form of the indicator is red and the ionized form is yellow.

What is the  $pK_a$  of the indicator?

Number
7.4

What is the color of this indicator in a solution with  $\text{pH} = 5$ ?

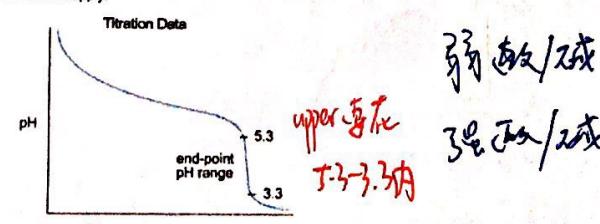
<input checked="" type="radio"/> red
<input type="radio"/> orange
<input type="radio"/> yellow



66.

The titration shown here has an equivalence point at  $\text{pH} = 4.3$ . Using [this table](#), identify which of the following indicators would be appropriate for this titration. Check all that apply.

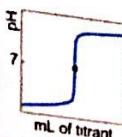
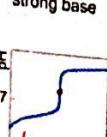
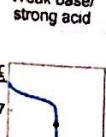
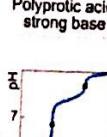
<input checked="" type="checkbox"/> bromophenol blue
<input type="checkbox"/> bromocresol purple
<input type="checkbox"/> bromothymol blue
<input checked="" type="checkbox"/> methyl orange
<input type="checkbox"/> phenolphthalein
<input checked="" type="checkbox"/> ethyl orange



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68.

Classify each titration curve as representing a strong acid titrated with a strong base, a weak acid titrated with a strong base, a strong base titrated with a strong acid, or a polyprotic acid titrated with a strong base.

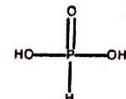
Strong acid/  
strong baseStrong base/  
strong acidWeak acid/  
strong baseWeak base/  
strong acidPolyprotic acid/  
strong base

fitter

69.

Phosphorous acid,  $\text{H}_3\text{PO}_3(\text{aq})$ , is a diprotic oxyacid that is an important compound in industry and agriculture.

$\text{pK}_{\text{a}1}$	$\text{pK}_{\text{a}2}$
1.30	6.70



Calculate the pH for each of the following points in the titration of 50.0 mL of a 2.4 M  $\text{H}_3\text{PO}_3(\text{aq})$  with 2.4 M  $\text{KOH}(\text{aq})$ .

(a) before addition of any KOH

Number  
0.49

(b) after addition of 25.0 mL of KOH

Number  
1.3

(c) after addition of 50.0 mL of KOH

Number  
4.0

(d) after addition of 75.0 mL of KOH

Number  
6.7

(e) after addition of 100.0 mL of KOH

Number  
10.39

Correct.

70.

The  $\text{pK}_b$  values for the dibasic base B are  $\text{pK}_{b1} = 2.10$  and  $\text{pK}_{b2} = 7.73$ . Calculate the pH at each of the following points in the titration of 50.0 mL of a 0.75 M B(aq) with 0.75 M HCl(aq).

(a) before addition of any HCl

Number  
12.87

(b) after addition of 25.0 mL of HCl

Number  
11.90

(c) after addition of 50.0 mL of HCl

Number  
9.085

(d) after addition of 75.0 mL of HCl

Number  
6.27

(e) after addition of 100.0 mL of HCl

Number  
3.44

Correct.



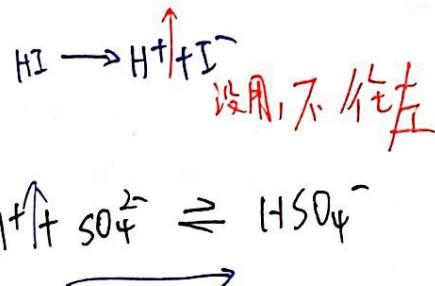
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## Focus 6 (2) 整理 Solubility

8.

Which salts will be more soluble in an acidic solution than in pure water?

<input type="checkbox"/>	CsClO <sub>4</sub>
<input type="checkbox"/>	CuI
<input checked="" type="checkbox"/>	CaCO <sub>3</sub>
<input checked="" type="checkbox"/>	Zn(OH) <sub>2</sub>
<input checked="" type="checkbox"/>	Ag <sub>2</sub> SO <sub>4</sub> *

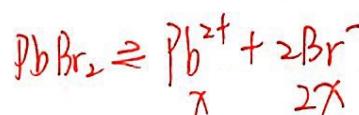


10.

The  $K_{sp}$  of PbBr<sub>2</sub> is  $6.60 \times 10^{-6}$ .

What is the molar solubility of PbBr<sub>2</sub> in pure water?

Number
$1.18 \times 10^{-2}$ M



\*

$$x \times (2x)^2 = 6.60 \times 10^{-6}$$

What is the molar solubility of PbBr<sub>2</sub> in 0.500 M KBr solution?

Number
0.0000264 M

$x \quad 0.5+x \quad x \times (0.5+x)^2 = 6.6 \times 10^{-6}$

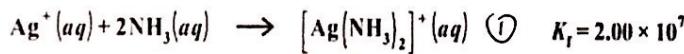
What is the molar solubility of PbBr<sub>2</sub> in a 0.500 M Pb(NO<sub>3</sub>)<sub>2</sub> solution?

Number
0.00182 M

$0.5+x \quad 2x \quad (0.5+x)(2x) = 6.6 \times 10^{-6}$

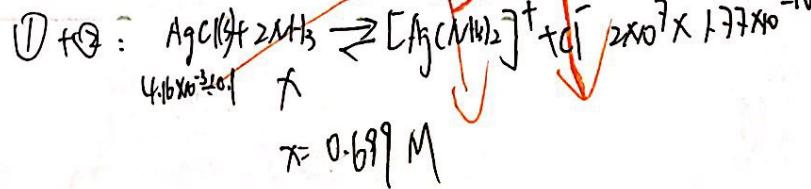
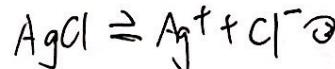
12.

Given the equation



determine the concentration of NH<sub>3</sub>(aq) that is required to dissolve 597 mg of AgCl(s) in 100.0 mL of solution.  
The  $K_{sp}$  of AgCl is  $1.77 \times 10^{-10}$ .

Number
0.783 M



$$0.699 + 0.0416 = 0.783$$



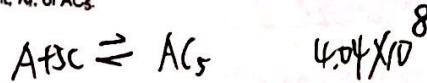
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13.

The generic metal A forms an insoluble salt AB(s) and a complex AC<sub>5</sub>(aq).

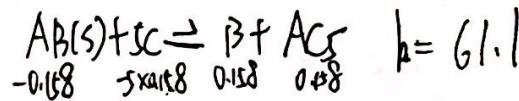
The equilibrium concentrations in a solution of AC<sub>5</sub> were found to be [A] = 0.100 M, [C] = 0.0190 M, and [AC<sub>5</sub>] = 0.100 M. Determine the formation constant, K<sub>f</sub>, of AC<sub>5</sub>.

Number
4.04 × 10 <sup>8</sup>



The solubility of AB(s) in a 1.000-M solution of C(aq) is found to be 0.158 M. What is the K<sub>sp</sub> of AB?

Number
1.51 × 10 <sup>-7</sup>

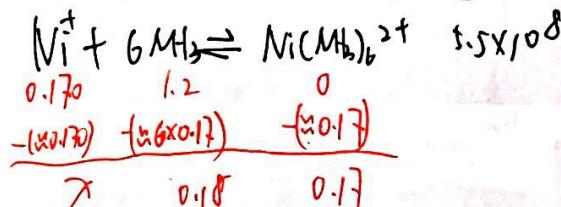
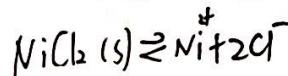


$$k = 4.04 \times 10^8 = 61.1$$

14.

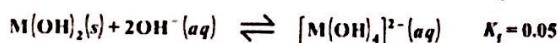
A 0.170-mole quantity of NiCl<sub>2</sub> is added to a liter of 1.20 M NH<sub>3</sub> solution. What is the concentration of Ni<sup>2+</sup> M ions at equilibrium? Assume the formation constant\* of Ni(NH<sub>3</sub>)<sub>6</sub><sup>2+</sup> is 5.5 × 10<sup>8</sup>.

Number
9.1 × 10 <sup>-6</sup>



15.

Consider an amphoteric hydroxide, M(OH)<sub>2</sub>(s), where M is a generic metal.



Estimate the solubility of M(OH)<sub>2</sub> in a solution buffered at pH = 7.0, 10.0, and 14.0.

pH = 7.0

Number
0.03

pH = 10.0

Number
3 × 10 <sup>-8</sup>

pH = 14.0

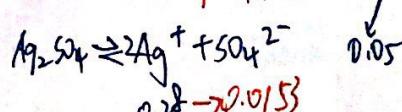
Number
0.05

19.

Sodium sulfate is slowly added to a solution containing 0.0500 M Ca<sup>2+</sup>(aq) and 0.0280 M Ag<sup>+</sup>(aq). What will be the concentration of Ca<sup>2+</sup>(aq) when Ag<sub>2</sub>SO<sub>4</sub>(s) begins to precipitate?

Solubility-product constants, K<sub>sp</sub>, can be found [here](#).

Number
0.00322



What percentage of the Ca<sup>2+</sup>(aq) can be precipitated from the Ag<sup>+</sup>(aq) by selective precipitation?

Number
93.6



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20.

Suppose you have a solution that contains 0.0410 M  $\text{Ca}^{2+}$  and 0.0910 M  $\text{Ag}^+$ . If solid  $\text{Na}_3\text{PO}_4$  is added to this mixture, which of the following phosphate species would precipitate out of solution first?

- $\text{Ca}_3(\text{PO}_4)_2$
- $\text{Ag}_3\text{PO}_4$
- $\text{Na}_3\text{PO}_4$

↓ 沉

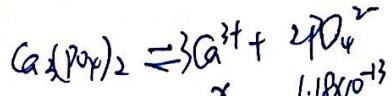
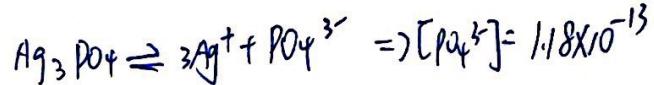
$$\text{K}_{\text{sp}} [\text{Ca}^{2+}]^3 [\text{PO}_4^{3-}]^2 = 2.0 \times 10^{-33}$$

(a) 沉!

$$\text{K}_{\text{sp}} = [\text{Ag}^+]^3 [\text{PO}_4^{3-}] = 8.89 \times 10^{-17}$$

When the second cation just starts to precipitate, what percentage of the first cation remains in solution?

Number	12.9	%
--------	------	---



$$x \quad 1.18 \times 10^{-13}$$

$$x^3 (1.18 \times 10^{-13})^2 = 2.07 \times 10^{-33}$$

$$7.5 \cdot 3 \times 10^{-3}$$

$$\frac{x}{0.04} = 12.9 \%$$

21.

Consider the following Gibbs energies at 25 °C.

Substance	$\Delta G^\circ_f$ (kJ · mol <sup>-1</sup> )
$\text{Ag}^*(\text{aq})$	77.1
$\text{Cl}^-(\text{aq})$	-131.2
$\text{AgCl}(\text{s})$	-109.8
$\text{Br}^-(\text{aq})$	-104.0
$\text{AgBr}(\text{s})$	-96.9

(a) Calculate  $\Delta G^\circ_{\text{rxn}}$  for the dissolution of  $\text{AgCl}(\text{s})$ .

Number	55.7	kJ · mol <sup>-1</sup>
--------	------	------------------------



(b) Calculate the solubility-product constant of  $\text{AgCl}$ .

Number	$2 \times 10^{-10}$
--------	---------------------

$$\ln b = - \frac{\Delta G^\circ}{RT} \star$$

(c) Calculate  $\Delta G^\circ_{\text{rxn}}$  for the dissolution of  $\text{AgBr}(\text{s})$ .

Number	70.0	kJ · mol <sup>-1</sup>
--------	------	------------------------

(d) Calculate the solubility-product constant of  $\text{AgBr}$ .

Number	$5 \times 10^{-13}$
--------	---------------------

22.

A solution containing a mixture of metal cations was treated as follows.

- Dilute HCl was added and a precipitate formed. The precipitate was filtered off.
- $\text{H}_2\text{S}$  was bubbled through the acidic solution. Again, a precipitate formed and was filtered off.
- The pH was raised to about 9 and  $\text{H}_2\text{S}$  was again bubbled through the solution. No precipitate formed.
- Finally, sodium carbonate was added and no precipitate formed.

What can be said about the presence of each of these groups of cations in the original solution?

Cation Group	Description	Present in the original solution?
$\text{Ag}^+, \text{Pb}^{2+}, \text{Hg}_2^{2+}$	form insoluble chlorides	At least one of these ions was present.
$\text{Bi}^{3+}, \text{Cd}^{2+}, \text{Cu}^{2+}, \text{Hg}^{2+}, \text{Pb}^{2+}, \text{Sb}^{3+}, \text{Sn}^{2+}, \text{Sn}^{4+}$	form acid-insoluble sulfides	At least one of these ions was present.
$\text{Al}^{3+}, \text{Co}^{2+}, \text{Cr}^{3+}, \text{Fe}^{2+}, \text{Fe}^{3+}, \text{Ni}^{2+}, \text{Mn}^{2+}, \text{Zn}^{2+}$	form base-insoluble sulfides or hydroxides	None of these ions were present.
$\text{Ba}^{2+}, \text{Ca}^{2+}, \text{Mg}^{2+}, \text{Sr}^{2+}$	form insoluble carbonates	None of these ions were present.
$\text{Li}^+, \text{Na}^+, \text{K}^+, \text{NH}_4^+$	completely soluble	unknown

At least one of these ions was present.

Unknown

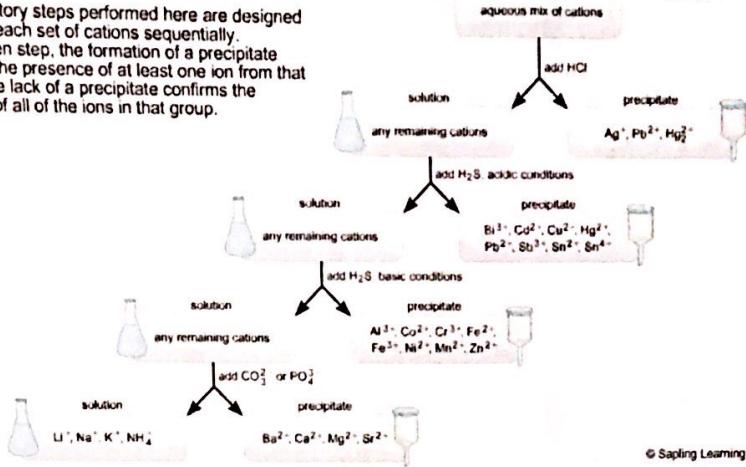
None of these ions were present.

All of these ions were present.



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The laboratory steps performed here are designed to test for each set of cations sequentially. In any given step, the formation of a precipitate indicates the presence of at least one ion from that group. The lack of a precipitate confirms the absence of all the ions in that group.



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23.

A student was given a solid containing a mixture of nitrate salts. The sample completely dissolved in water and upon addition of dilute HCl, no precipitate formed. The pH was lowered to about 1 and H<sub>2</sub>S was bubbled through the solution. No precipitate formed. The pH was adjusted to 8 and H<sub>2</sub>S was again bubbled in. This time, a precipitate formed.

Which compounds might have been present in the unknown?

<input checked="" type="checkbox"/> Ca(NO <sub>3</sub> ) <sub>2</sub>	③ H <sub>2</sub> S
<input type="checkbox"/> Pb(NO <sub>3</sub> ) <sub>2</sub>	② H <sub>2</sub> S
<input type="checkbox"/> Cu(NO <sub>3</sub> ) <sub>2</sub>	② H <sub>2</sub> S
<input checked="" type="checkbox"/> Zn(NO <sub>3</sub> ) <sub>2</sub>	③
<input checked="" type="checkbox"/> Ni(NO <sub>3</sub> ) <sub>2</sub>	③
<input checked="" type="checkbox"/> KNO <sub>3</sub>	→ known
<input type="checkbox"/> AgNO <sub>3</sub>	① HCl
<input checked="" type="checkbox"/> Cr(NO <sub>3</sub> ) <sub>3</sub>	②

24.

A solution containing a mixture of metal cations was treated with dilute HCl and no precipitate formed. Next, H<sub>2</sub>S was bubbled through the acidic solution. A precipitate formed and was filtered off. Then, the pH was raised to about 8 and H<sub>2</sub>S was again bubbled through the solution. A precipitate again formed and was filtered off. Finally, the solution was treated with a sodium carbonate solution, which resulted in no precipitation. Which metal ions were definitely present, which were definitely absent, and which may or may not have been present in the original mixture?

Definitely present	Definitely absent	Possibly present
	Ag <sup>+</sup>	Cu <sup>2+</sup>
	Ca <sup>2+</sup>	Mn <sup>2+</sup>
	Mg <sup>2+</sup>	Fe <sup>2+</sup>
	Pb <sup>2+</sup>	Co <sup>2+</sup>
	Hg <sup>2+</sup>	Sn <sup>2+</sup>
		K <sup>+</sup>
		Hg <sup>2+</sup>
		Sb <sup>3+</sup>

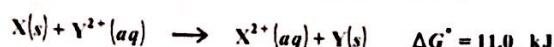


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### Focus 6 (3) 整理 Electrochemistry

12.

Calculate the standard potential,  $E^\circ$ , for this reaction from its  $\Delta G^\circ$  value.



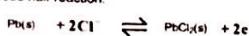
$$E^\circ = \boxed{\begin{matrix} \text{Number} \\ -0.0570 \end{matrix}} \text{ V}$$

$$\Delta G^\circ = -n N_A e E^\circ = -n F E^\circ$$

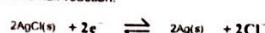
13.

Complete the half-reactions for the cell shown here, and show the shorthand notation for the cell by dragging labels to the correct position. The electrode on the left is the anode, and the one on the right is the cathode.

Anode half-reaction:

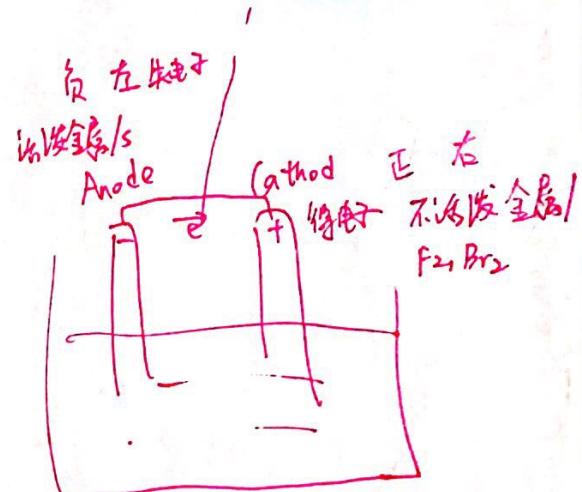
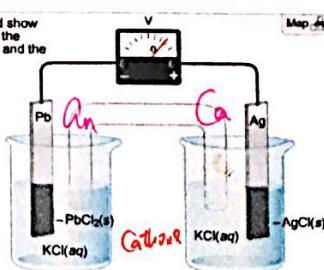
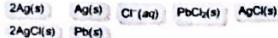
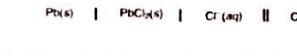


Cathode half-reaction:



Anode

Shorthand notation:



17.

A galvanic (voltaic) cell consists of an electrode composed of nickel in a 1.0 M nickel(II) ion solution and another electrode composed of copper in a 1.0 M copper(II) ion solution, connected by a salt bridge. Calculate the standard potential for this cell at 25 °C. Standard reduction potentials can be found [here](#).

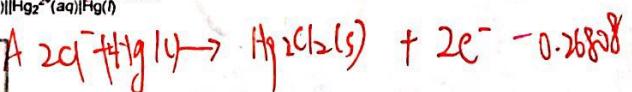
$$E_{\text{cell}}^\circ = \boxed{\begin{matrix} \text{Number} \\ 0.60 \end{matrix}} \text{ V}$$

$$\begin{array}{l} + \text{Cu red: } 0.34 \text{ V} \\ - \text{Ni red: } 0.26 \text{ V} \\ \therefore 0.6 \text{ V} \end{array}$$

18.

Predict the standard potential for the galvanic cell. Standard reduction potentials can be found [here](#).  
Anode (cathode)  
 $Hg(l)|Hg_2Cl_2(s)||Cl^-(aq)||Hg_2^{2+}(aq)|Hg(l)$

$$\boxed{\begin{matrix} \text{Number} \\ 0.5292 \end{matrix}} \text{ V}$$



19.

Rank these species by their ability to act as an oxidizing agent.

Best oxidizing agent

red/ox

$Br_2$

$Pb^{2+}$

$Zn^{2+}$

$Na^+$

red/ox

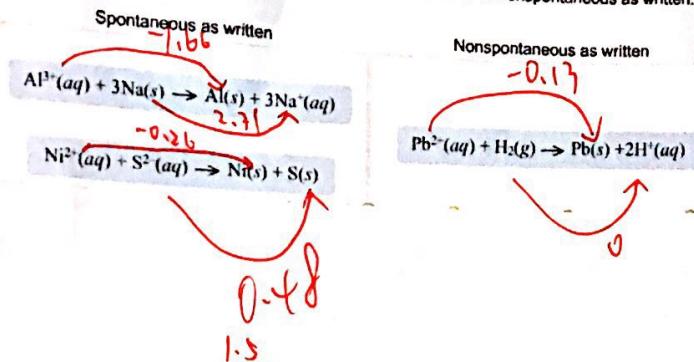
Poorest oxidizing agent



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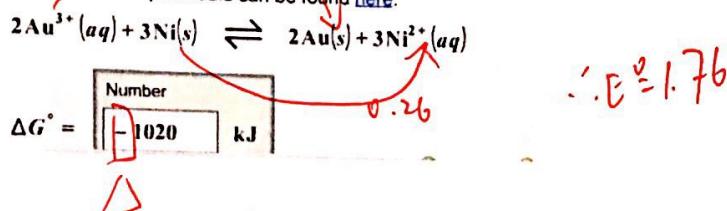
20.

Based on the sign of  $E_{\text{cell}}^{\circ}$ , classify these reactions as spontaneous or nonspontaneous as written.  
Assume standard conditions.



21.

Calculate the standard free-energy change for the following reaction at 25 °C.  
Standard reduction potentials can be found [here](#).



22.

Using a [table of standard reduction potentials](#), determine the best answer to the following questions.

a) Which of the following reagents would oxidize Fe to  $\text{Fe}^{2+}$ , but not Pb to  $\text{Pb}^{2+}$ ?

- Co
- $\text{Ca}^{2+}$
- $\text{Co}^{2+}$
- $\text{Br}^-$
- Ca
- $\text{Br}_2$

b) Which of the following reagents would oxidize Ag to  $\text{Ag}^+$ , but not F<sup>-</sup> to  $\text{F}_2$ ?

- $\text{Co}^{2+}$
- $\text{Ca}^{2+}$
- Co
- Ca
- $\text{Br}^-$
- $\text{Br}_2$

23.

Given the following half-reactions and their respective standard reduction potentials

1.  $\text{Cu}^{3+} + 2e^- \rightarrow \text{Cu}^+$   $E_1^\circ = +1.28 \text{ V}$
2.  $\text{Cu}^{2+} + e^- \rightarrow \text{Cu}^+$   $E_2^\circ = +0.15 \text{ V}$
3.  $\text{Cu}^{2+} + 2e^- \rightarrow \text{Cu}(s)$   $E_3^\circ = +0.34 \text{ V}$
4.  $\text{Cu}^+ + e^- \rightarrow \text{Cu}(s)$   $E_4^\circ = +0.52 \text{ V}$

$$\Delta G_1 = -nFE = -2 \times 1.28F$$

$$\Delta G_2 = -nFE = -1 \times 0.15F$$

$$\Delta G_1 - \Delta G_2 = -nEF$$

calculate the standard reduction potential for the reduction half-reaction of Cu(III) to Cu(II).



$E^\circ = \boxed{2.41} \text{ V}$



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24.

Complete this table relating the values of  $E_{\text{cell}}^{\circ}$  and  $\Delta G^{\circ}$  to  $K$

$K$	$E_{\text{cell}}^{\circ}$	$\Delta G^{\circ}$
< 1	< 0	> 0
= 1	= 0	= 0
> 1	> 0	< 0

[Explanation](#) [Previous](#)

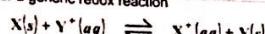
First, consider the equations relating  $\Delta G^{\circ}$  and  $K$  to  $E_{\text{cell}}^{\circ}$ .

$$\Delta G^{\circ} = -RT \ln(K)$$

$$\Delta G^{\circ} = -nFE_{\text{cell}}^{\circ} \quad E_{\text{cell}}^{\circ} = \frac{\Delta G^{\circ}}{nF}$$

26.

Consider a generic redox reaction:



then suppose that the coefficients in the redox reaction are doubled.

How will the following quantities be affected for a voltaic cell under nonstandard conditions?

Doubled	Halfed	Squared	No Change
$n$			$E$
In Q		$Q$	$E'$

Note that  $n$  is written as  $y_6$  or  $z$  in some textbooks.

$$\begin{aligned} E &= E^{\circ} - \frac{RT}{nF} \ln Q \\ &= E^{\circ} - \frac{RT}{2nF} \ln \left( \frac{[X^{+}]^2}{[Y^{+}]^2} \right) \end{aligned}$$

27.

What would the potential of a standard hydrogen electrode (S.H.E.) be if it was under the following conditions?

$$[\text{H}^{+}] = 0.57 \text{ M} \quad P_{\text{H}_2} = 3.1 \text{ atm} \quad T = 298 \text{ K}$$

Number  
-0.029 V

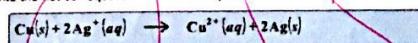
$$E = E^{\circ} - \frac{RT}{nF} \ln \alpha = E^{\circ} - \frac{0.0592}{n} \log \alpha$$

28.

For the following electrochemical cell:



write the net cell equation. Phases are optional. Do not include the concentrations.



Calculate the following values at 25.0 °C using standard potentials as needed.

$E_{\text{cell}}^{\circ} =$  Number  
0.46 V

$\Delta G_{\text{rxn}}^{\circ} =$  Number  
-89 kJ/mol

$E_{\text{cell}} =$  Number  
0.524 V

$\Delta G_{\text{rxn}} =$  Number  
-101 kJ/mol

29.

Anode

Anode electrolyte

Cathode electrolyte

Cathode

The voltage generated by the zinc concentration cell described by:



is 25.0 mV at 25 °C. Calculate the concentration of the  $\text{Zn}^{2+}(\text{aq})$  ion at the cathode.

Number  
0.70 M

$$25 \times 10^{-3} = 0 - \frac{0.0592}{2} \left[ \log \frac{0.1}{x} \right]$$

$$x = 0.699 \text{ M}$$



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30.

When an ion-selective electrode for  $X^+$  was immersed in 0.0510 M XCl, the measured potential was 0.0370 V. What is the concentration of  $X^+$  when the potential is 0.0520 V? Assume that the electrode follows the Nernst equation, the temperature is at 25°C, and that the activity coefficient of  $X^+$  is 1.

$$[\text{X}^+] = \boxed{0.0914} \text{ M}$$

单电极  $E = \text{constant} + \frac{0.05916}{n} \times \log [X]$

$$0.037 = C + \frac{0.05916}{1} \times \log 0.05 \Rightarrow C = 0.113 \text{ M}$$

$$0.052 = 0.113 + \frac{0.05916}{1} \times \log X \Rightarrow X = 0.0914$$

35.

A current of 3.89 A is passed through a Pb(NO<sub>3</sub>)<sub>2</sub> solution. How long (in hours) would this current have to be applied to plate out 7.60 g of lead?

$$\boxed{0.505} \text{ h}$$

$$7.60 \text{ Pb} = 0.0367 \text{ mol} = 0.07336 \text{ mol e}^{-} = \frac{0.07336}{6.02 \times 10^{-23}} \text{ mol e}^{-}$$

$$3.89 \text{ A} = 3.89 \text{ C/s} = 3.89 \div (1.6 \times 10^{-19}) \text{ mol e}^{-}$$

$$\frac{a}{b} = 0.505 \text{ h}$$

36.

Current is applied to a molten mixture of AgF, ZnCl<sub>2</sub>, and CaS. Standard potentials may be found [here](#).

What is produced at the cathode?

- Ag
- Ca
- F<sub>2</sub>
- S
- Zn
- Cl<sub>2</sub>

What is produced at the anode?

- Ca
- Zn
- Cl<sub>2</sub>
- S
- F<sub>2</sub>
- Ag

38.

Consider two cells, the first with Al and Ag electrodes, and the second with Zn and Ni electrodes, each in appropriate 1.00 M solutions of their ions.

a) If connected as voltaic cells in series, which two metals are plated, and what is the total potential?

- Al(s)
- Ag(s)
- Zn(s)
- Ni(s)

$$E^\circ = \boxed{2.96} \text{ V}$$

正接

b) If connected such that one cell acts as a battery to power the other as an electrolytic cell, which two metals are plated, and what is the total potential?

- Al(s)
- Ag(s)
- Zn(s)
- Ni(s)

$$E^\circ = \boxed{1.96} \text{ V}$$

反接，极为负

c) If 2.00 g of metal is plated in the voltaic cell, how much metal is plated in the electrolytic cell?

$$\boxed{0.606} \text{ g}$$



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# Focus 7(1) 整理 Kinetics

1.

The rate of the following reaction is 0.720 M/s. What is the relative rate of change of each species in the reaction?



有负!

$$\frac{\Delta[A]}{\Delta t} = \begin{array}{|c|c|} \hline \text{Number} & \\ \hline -0.720 & \text{M/s} \\ \hline \end{array}$$

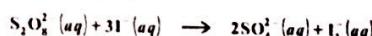
$$\frac{\Delta[B]}{\Delta t} = \begin{array}{|c|c|} \hline \text{Number} & \\ \hline -2.880 & \text{M/s} \\ \hline \end{array}$$

$$\frac{\Delta[C]}{\Delta t} = \begin{array}{|c|c|} \hline \text{Number} & \\ \hline 1.440 & \text{M/s} \\ \hline \end{array}$$

relative rate  
rate of reaction (of -)  
average rate

2.

The "iodine clock reaction" is a popular chemical demonstration. As part of that demonstration, the  $I_3^-$  ion is generated in the reaction



In one trial, the unique rate of reaction was  $8.69 \mu\text{mol} \cdot \text{L}^{-1} \cdot \text{s}^{-1}$ .

a. What was the rate of reaction of iodide ions?

$$\begin{array}{|c|c|} \hline \text{Number} & \\ \hline 26.07 & \mu\text{mol} \cdot \text{L}^{-1} \cdot \text{s}^{-1} \\ \hline \end{array}$$

无负!

b. What was the rate of formation of sulfate ions?

$$\begin{array}{|c|c|} \hline \text{Number} & \\ \hline 17.38 & \mu\text{mol} \cdot \text{L}^{-1} \cdot \text{s}^{-1} \\ \hline \end{array}$$

3.

The decomposition of  $N_2O_5$  can be described by the equation



Given these data for the reaction at  $45^\circ\text{C}$  in carbon tetrachloride solution, calculate the average rate of reaction for each successive time interval.

t (s)	[ $N_2O_5$ ] (M)
0	1.76
195	1.56
536	1.26
825	1.05

Interval:	0 s to 195 s	195 s to 536 s	536 s to 825 s
Reaction rate:	$5.13 \times 10^{-4} \text{ M/s}$	$4.40 \times 10^{-4} \text{ M/s}$	$3.63 \times 10^{-4} \text{ M/s}$

7.

For each reaction order, identify the proper units for the rate constant, k. Not all choices will be used.

Zero order	First order	Second order	Third order
$\frac{\text{M}}{\text{s}}$	$\frac{1}{\text{s}}$	$\frac{1}{\text{M} \cdot \text{s}}$	$\frac{1}{\text{M}^2 \cdot \text{s}}$
$\frac{\text{M}^2}{\text{s}}$			

take second order for example

$$\text{rate} = k [A]^2$$

$\downarrow$

$\frac{1}{\text{M} \cdot \text{s}}$



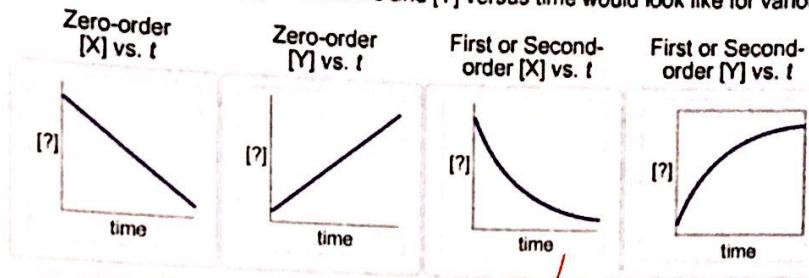
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11.

For the reaction



identify what the graphs of [X] versus time and [Y] versus time would look like for various orders.



随着  $t \uparrow$ ,  $[X] \downarrow$ ,  $\text{rate} = k[X] \downarrow$ , 斜率减小.

13.

Using the given data, calculate the rate constant of this reaction.



Trial	[A] (M)	[B] (M)	Rate (M/s)
1	0.290	0.350	0.0131
2	0.290	0.875	0.0819
3	0.464	0.350	0.0210

$$\textcircled{1} \textcircled{2} \quad A \text{ 同}, \text{ rate} = k[B]^t$$

$$\frac{0.931}{0.0819} = \left(\frac{0.875}{0.350}\right)^t \Rightarrow t = 2$$

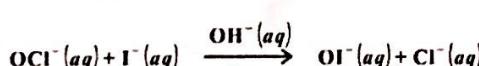
$$\textcircled{1} \textcircled{3} \quad B \text{ 同}, \text{ rate} = k[A]^t \\ \Rightarrow t = 1$$

$$\therefore \text{rate} = k[A][B]^2$$

$$\therefore k = 0.369$$

14.

Consider this initial-rate data at a certain temperature for the reaction described by



Determine the rate law and the value of the rate constant for this reaction.

$$\text{rate} = k \frac{[OCl^-][I^-]}{[OH^-]}$$

Trial	$[OCl^-]_0$ (M)	$[I^-]_0$ (M)	$[OH^-]_0$ (M)	Initial rates (M/s)
1	0.00191	0.00191	0.550	0.000458
2	0.00191	0.00350	0.550	0.000840
3	0.00288	0.00191	0.787	0.000483
4	0.00191	0.00350	0.891	0.000518

$$\textcircled{1} \textcircled{2}, [OCl^-], [I^-] \text{ 同}, \text{ rate} = k[I^-]^t \Rightarrow t = 1$$

$$\textcircled{1} \textcircled{4}, [OCl^-], [I^-] \text{ 不同}, \text{ rate} = k[OH^-]^t \Rightarrow t = 1$$

$$\textcircled{1} \textcircled{3}, [I^-] \text{ 同}, \text{ rate} = k[OCl^-]t [OH^-]^{t-1} \Rightarrow t = 1$$

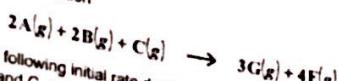
$$k = \frac{69.05}{s^{-1}}$$



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15.

For the reaction



the following initial rate data was collected, where  $[A]_0$ ,  $[B]_0$ , and  $[C]_0$  are the initial concentrations of A, B, and C, respectively.

Experiment	$[A]_0$ (mmol L <sup>-1</sup> )	$[B]_0$ (mmol L <sup>-1</sup> )	$[C]_0$ (mmol L <sup>-1</sup> )	Initial rate (mmol L <sup>-1</sup> s <sup>-1</sup> )
1	13.0			
2	26.0	100.0	300.0	
3	26.0	100.0	225.0	5.20
4	13.0	200.0	75.0	20.8
			150.0	2.60

Identify the order of each reactant.

Reactant A

- zero-order reactant
- first-order reactant
- second-order reactant

Reactant B

- zero-order reactant
- first-order reactant
- second-order reactant

Reactant C

- zero-order reactant
- first-order reactant
- second-order reactant

↓ 答案 C

What is the overall order of the reaction?

Number

3

Write the rate law for the reaction where k is the rate constant.

Continued below

$$\text{rate} = k[A][B]^2$$

Calculate the rate constant, k, and identify its units.

Con

Number

 $2 \times 10^{-5}$ 

- s<sup>-1</sup>
- L · mmol<sup>-1</sup> · s<sup>-1</sup>
- L<sup>2</sup> · mmol<sup>-2</sup> · s<sup>-1</sup>

Con

Determine the initial rate of the reaction when  $[A]_0 = 4.27 \text{ mmol L}^{-1}$ ,  $[B]_0 = 0.130 \text{ mmol L}^{-1}$ , and  $[C]_0 = 12.0 \text{ mmol L}^{-1}$ .

Number

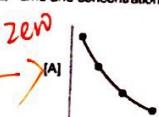
 $1.44 \times 10^{-6}$ mmol · L<sup>-1</sup> · s<sup>-1</sup>

Correct.

21.

For  $A \rightarrow \text{products}$ , time and concentration data were collected and plotted as shown here.

[A] (M)	t (s)
0.900	0.0
0.474	30.0
0.321	60.0
0.243	90.0



$$\frac{1}{[A]} = \frac{1}{[A]_0} + kt$$

Determine the reaction order, the rate constant, and the units of the rate constant.

order =

Number

2

Number

0.033

Units

M<sup>-1</sup> s<sup>-1</sup>

$$[A]_t = \frac{[A]_0}{1 + kt[A]_0}$$

22.

$$[A]_t = [A]_0 e^{-kt} \quad [A]_t = [A]_0 e^{-kt}$$

$$[A]_t = [A]_0 e^{-kt}$$

The following data were collected at 780 K for the reaction  $H_2(g) + I_2(g) \rightarrow 2HI(g)$ 

a. Using a graphing calculator or software, plot the data in an appropriate fashion to determine the order of the reaction.

- 0
- 1
- 2

Time (s)	$[I_2]$ (mmol L <sup>-1</sup> )
0	1.00
1.0	0.43
2.0	0.27
3.0	0.20
4.0	0.16

b. From the graph, determine the rate constant for the consumption of  $I_2$ .

Number

1325.6

- mol L<sup>-1</sup> s<sup>-1</sup>
- s<sup>-1</sup>
- L · mol<sup>-1</sup> · s<sup>-1</sup>

$$① [I_2] \ln[I_2] \frac{1}{[I_2]}$$

↓ 答案

$$t_{\frac{1}{2}} = \frac{[\ln 2]}{k}$$

$$t_{\frac{1}{2}} = \frac{\ln 2}{k} = \frac{0.693}{k}$$

$$t_{\frac{1}{2}} = \frac{1}{k[A]}$$

↑  $\ln[A] \ln \frac{1}{2} / k$  ?



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23.

After 79.0 min, 39.0% of a compound has decomposed. What is the half-life of this reaction assuming first-order kinetics?

Number
111.08
min

$$\ln: 0.61 [A_0] = [A_0] e^{-kt} \Rightarrow k = 1.043 \times 10^{-4}$$

$$0.5 [A_0] = [A_0] e^{-tk} \Rightarrow t = 6646 \text{ s} = 110.8 \text{ min}$$

24.

For each of the following cases, identify the order with respect to the reactant, A.

Case  $A \rightarrow \text{products}$ 

Order

The half-life of A decreases as the initial concentration of A decreases.

Number
0

$$t_{\frac{1}{2}} = \frac{[A]}{2k}$$

$\leftarrow$  A twofold increase in the initial concentration of A leads to a fourfold increase in the initial rate.

Number
2

$$\text{first } t_{\frac{1}{2}} = \frac{\ln 2}{k} = \frac{0.693}{k}$$

A twofold increase in the initial concentration of A leads to a 1.41-fold increase in the initial rate.

Number
0.5

$$\text{second } t_{\frac{1}{2}} = \frac{1}{k[A]}$$

The time required for [A] to decrease from  $[A]_0$  to  $[A]_0/2$  is equal to the time required for [A] to decrease from  $[A]_0/2$  to  $[A]_0/4$ .

Number
1

The rate of decrease of [A] is a constant.

Number
0

25.

The rate constant for the reaction is  $0.640 \text{ M}^{-1} \cdot \text{s}^{-1}$  at  $200^\circ\text{C}$ .

 $A \rightarrow \text{products}$ 

简单性，它是 second order !!!

If the initial concentration of A is  $0.00960 \text{ M}$ , what will be the concentration after 815 s?

Number
$1.60 \times 10^{-3}$
M

$$\frac{1}{[A]_t} = \frac{1}{[A]_0} + kt$$

26.

A particular reactant decomposes with a half-life of 143 s when its initial concentration is  $0.296 \text{ M}$ . The same reactant decomposes with a half-life of 233 s when its initial concentration is  $0.182 \text{ M}$ .

Determine the reaction order.

<input type="radio"/> 0
<input type="radio"/> 1
<input checked="" type="radio"/> 2

$$[A] \uparrow, t \downarrow, \text{ so cond, } \frac{1}{[A]}$$

What is the value and unit of the rate constant for this reaction?

Number
0.0236
$\text{M}^{-1} \cdot \text{s}^{-1}$

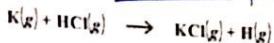


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与系数成正比!!!

27.

Consider the following elementary reaction equation.



What is the order with respect to K?

Number
1

What is the overall order of the reaction?

Number
2

Classify the reaction as unimolecular, bimolecular, or termolecular.

- termolecular
- bimolecular
- unimolecular

→ 有几种分子决定反应速度?

29.

A mechanism proposed for the oxidation of iodide ion,  $I^-$ , by the hypochlorite ion,  $ClO^-$ , in aqueous solution is shown below.

1.  $ClO(aq) + H_2O(l) \rightleftharpoons HClO(aq) + OH^-(aq)$  fast in both directions  $\rightleftharpoons$  equilibrium
2.  $I^-(aq) + HClO(aq) \rightarrow HIO(aq) + Cl^-(aq)$  slow
3.  $HIO(aq) + OH^-(aq) \rightarrow IO^-(aq) + H_2O(l)$  fast

Write the rate law for the formation of  $IO^-$  implied by this mechanism.

$$\text{rate} = k \frac{[ClO][I^-]}{[OH^-]}$$

① 先看 slow

$$\begin{matrix} [HClO] & [H_2O] \\ [Cl^-] \\ [IO^-] & [HIO] \end{matrix}$$

$$\text{rate} = k[I^-][HClO]$$

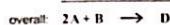
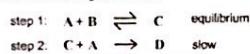
而  $[HClO]$  是中间产物

$$\text{② 由(1) } k_1[ClO] = k_2[HClO][OH^-]$$

$$\therefore \text{rate}_2 = k \frac{[I^-][ClO]}{[OH^-]} \cdot \frac{k_1}{k_2}$$

31.

Consider the following mechanism.



Determine the rate law for the overall reaction (where the overall rate constant is represented as  $k$ ).

$$\text{rate} = k[A]^2[B]$$

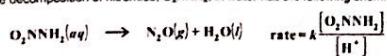
$$\text{由② rate} = k_2[C][A]$$

$$\text{由① } k_1[A][B] = k_2[C]$$

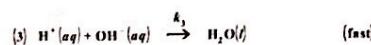
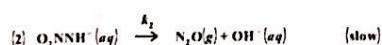
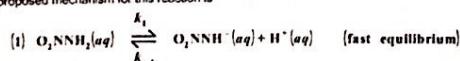
$$\therefore \text{rate} = k[A]^2[B]$$

32.

The decomposition of nitramide,  $O_2NNH_2$ , in water has the following chemical equation and rate law.



A proposed mechanism for this reaction is



What is the relationship between the observed value of  $k$  and the rate constants for the individual steps of the mechanism?

$$k = \frac{k_2 k_1}{k_{-1}} k_3$$

Drag the symbols into the numerator or denominator as needed.

Correct

$$\text{rate} = k_2 [O_2NNH^+]$$

$$k_2 [O_2NNH^+] [H^+] = k_1 [O_2NNH_2]$$

$$\therefore \frac{k_2 \times k_1}{k_{-1}}$$



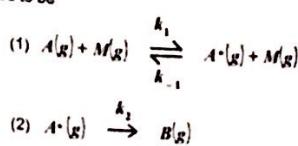
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33.

The mechanism for the reaction described by the equation



is suggested to be



where A(g) is  $\text{CH}_3\text{NC}(g)$ , M(g) is any gas molecule,  $A^*(g)$  is  $\text{CH}_3\text{NC}^*(g)$  (an energized gas molecule), and B(g) is  $\text{CH}_3\text{CN}(g)$ .

(a) Assuming that  $[A^*]$  is governed by steady-state conditions, derive the rate law for the production of  $\text{CH}_3\text{CN}(g)$  in terms of [A], [M], and the appropriate k values and enter it in the space below.

$$\text{rate of reaction} = \frac{\Delta[\text{CH}_3\text{CN}]}{\Delta t} = \frac{k_1 k_2 [A][M]}{k_{-1}[M] + k_1}$$

rate  $[B] = \text{rate } [A^*]$  无 fast, slow ?  $\rightarrow$  中间产物，其生成消耗速率相等！

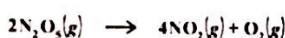
(b) At high pressures of gas the overall rate law becomes

- zero order
- half order
- first order
- second order
- third order

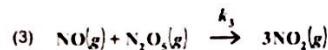
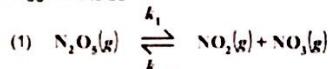
(c) At low pressures of gas the overall rate law becomes

- zero order
- half order
- first order
- second order
- third order

The mechanism for the reaction described by the equation



is suggested to be



Assuming that  $[\text{NO}_3]$  is governed by steady-state conditions, derive the rate law for the production of  $\text{O}_2(g)$  and enter it in the space below.

$$\text{rate of reaction} = \frac{\Delta[\text{O}_2]}{\Delta t} = \frac{k_1 k_2 [\text{N}_2\text{O}_5]}{k_{-1} + k_1}$$

$$k_1 [\text{A}][\text{M}] - k_2 [\text{A}^*][\text{M}] - k_2 [\text{A}^*] = 0$$

$$[\text{A}^*] = \frac{k_1 [\text{A}][\text{M}]}{k_2 [\text{M}] + k_2}$$

$$\text{rate B} = k_2 [\text{A}^*]$$

$$\text{rate } \frac{k_2 [\text{A}^*][\text{M}]}{k_1 [\text{A}][\text{M}] + k_2}$$

$\Rightarrow P \uparrow \uparrow, [\text{M}] \uparrow \uparrow, k_2 \text{ 增大}, \text{first}$   
 $\Rightarrow P \downarrow \downarrow, [\text{M}] \downarrow \downarrow, k_2 \text{ 减小}, \text{second}$

$$k_1 [\text{N}_2\text{O}_5] - k_1 [\text{NO}_2][\text{NO}_3] - k_2 [\text{NO}_2][\text{NO}_3] = 0$$

$$[\text{NO}_3] = \frac{k_1 [\text{N}_2\text{O}_5]}{k_1 [\text{NO}_2] + k_2 [\text{NO}_2]}$$

$$\text{(1) rate } [\text{N}_2\text{O}_5] = k_1 [\text{N}_2\text{O}_5] - k_1 [\text{NO}_2][\text{NO}_3]$$

$$\begin{aligned} \text{rate } [\text{N}_2\text{O}_5] &= k_1 [\text{N}_2\text{O}_5] - \frac{k_1 k_2 [\text{N}_2\text{O}_5]}{k_1 + k_2} \\ &= \frac{k_1 k_2 [\text{N}_2\text{O}_5]}{k_1 + k_2} \end{aligned}$$

36.

Consider this reaction data:



T (K)	k (s <sup>-1</sup> )
225	0.385
875	0.808

If you were going to graphically determine the activation energy of this reaction, what points would you plot?

x	y
Number $4.44 \times 10^{-3}$	Number -0.9545
Number $1.14 \times 10^{-3}$	Number -0.2132

point 1:  
point 2:

To avoid round errors, use at least three significant figures in all.

Determine the rise, run, and slope of the line formed by these points.

rise	run	slope
Number 0.7413	Number $-3.3 \times 10^{-3}$	Number -224.64

$$(\ln k - \text{intercept}) + \text{slope} \times \frac{1}{T}$$

$$\ln b = C_A - \frac{E_a}{RT}$$

What is the activation energy of this reaction?

Number 1867.739	J/mol
--------------------	-------

Correct.



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40.

- The rate constant for the conversion of cyclopropane into propene was determined at several temperatures.
- a. Use a graphing calculator or standard graphing software to make an Arrhenius plot and calculate the activation energy for the reaction.

$$E_a = \frac{2.72 \times 10^2}{\text{kJ} \cdot \text{mol}^{-1}}$$

$$\ln k = \ln A - \frac{E_a}{RT}$$

T (K)	k (s <sup>-1</sup> )
750.	$1.8 \times 10^{-4}$
800.	$2.7 \times 10^{-3}$
850.	$3.0 \times 10^{-2}$
900.	0.26

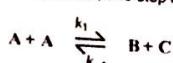
- b. Calculate the rate constant at 564.0 °C.

$$k = \frac{0.0165}{\text{s}^{-1}}$$

figur

41.

For the reversible, one-step reaction shown below,



the rate constant for the forward reaction,  $k_1$ , is  $269 \text{ L} \cdot \text{mol}^{-1} \cdot \text{min}^{-1}$  and the rate constant for the reverse reaction,  $k_{-1}$ , is  $373 \text{ L} \cdot \text{mol}^{-1} \cdot \text{min}^{-1}$  at a given temperature. The activation energy for the forward reaction is  $44.2 \text{ kJ} \cdot \text{mol}^{-1}$ , while the activation energy for the reverse reaction is  $20.0 \text{ kJ} \cdot \text{mol}^{-1}$ .

Determine the equilibrium constant, K, of this reaction.

$$K = \frac{0.721}{\text{---}}$$

平衡  $K = \frac{k_1}{k_{-1}} = \frac{k_1}{k_2} \times \frac{k_2}{k_3} \times \dots$



Determine whether this reaction is endothermic or exothermic.

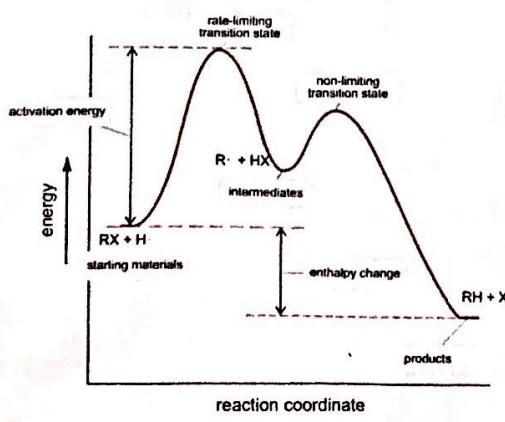
endothermic  
 exothermic

What effect will raising the temperature of the reaction have on the rate constants and the equilibrium constant?

- Raising the temperature will increase the reverse rate constant,  $k_{-1}$ , more than it will increase the forward rate constant,  $k_1$ , resulting in a decrease in the equilibrium constant, K.
- Raising the temperature will increase the forward rate constant,  $k_1$ , and reverse rate constant,  $k_{-1}$ , equally, leaving the equilibrium constant, K, unchanged.
- Raising the temperature will increase the forward rate constant,  $k_1$ , more than it will increase the reverse rate constant,  $k_{-1}$ , resulting in an increase in the equilibrium constant, K.
- Raising the temperature will not affect either rate constant or the equilibrium constant, K.

42.

Label the energy diagram for a two-step reaction.



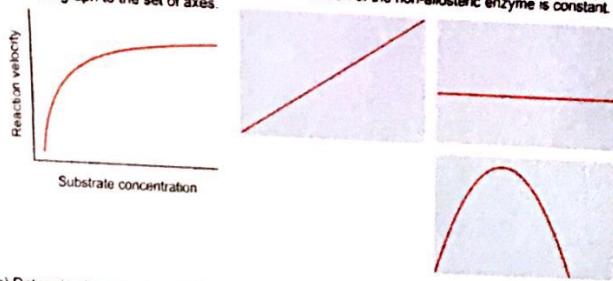
Correct.



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47.

(a) Determine which of the following graphs represents the relationship of reaction rate (velocity) and substrate concentration when the enzyme concentration of the non-allosteric enzyme is constant. Move the correct graph to the set of axes.



(b) Determine how reaction rate (velocity) varies with substrate concentration.

Rate increases

Rate decreases

Correct

additional substrate is added when substrate concentration is low

additional substrate is added when substrate concentration is very high  
substrate is added when enzyme is saturated with substrate

48.

The presence of a catalyst provides a reaction pathway in which the activation energy of a reaction is reduced by 43.00 kJ·mol<sup>-1</sup>.

Uncatalyzed: A → B       $E_a = 115.00 \text{ kJ} \cdot \text{mol}^{-1}$

Catalyzed: A → B       $E_a = 72.00 \text{ kJ} \cdot \text{mol}^{-1}$

Determine the factor by which the catalyzed reaction is faster than the uncatalyzed reaction at 293.0 K if all other factors are equal.

Number  
 $4.63 \times 10^7$  times faster

Determine the factor by which the catalyzed reaction is faster than the uncatalyzed reaction at 339.0 K if all other factors are equal.

Number  
 $4.22 \times 10^6$  times faster

$$\ln k = \ln A - \frac{E_a}{RT}$$
$$\ln \frac{k_2}{k_1} = \frac{E_a}{R} \left( \frac{1}{T_1} - \frac{1}{T_2} \right)$$
$$\ln \frac{k_2}{k_1} = \frac{T_1 - T_2}{R T_1 T_2}$$



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