This print-out should have 50 questions. Multiple-choice questions may continue on the next column or page – find all choices before answering.

001 10.0 points

A reaction has a negative change in entropy. This reaction can only be spontaneous if...

1. heat is absorbed by the system at any temperature

2. heat is released at any temperature

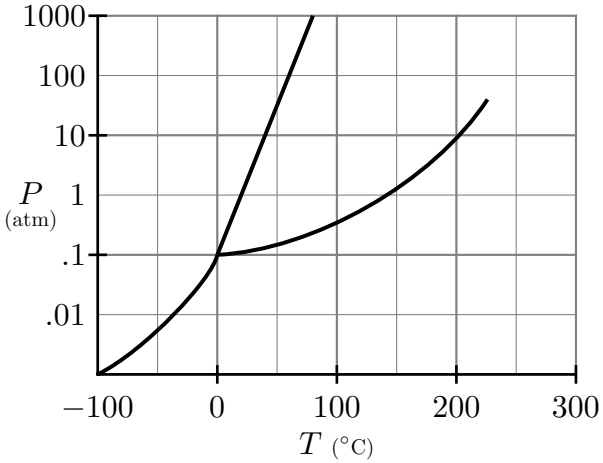
3. heat is absorbed at a sufficiently high temperature

4. None of these choices are correct because a reaction with a negative change in entropy can never be spontaneous

5. heat is released at a sufficiently low temperature

002 (part 1 of 2) 10.0 points

Use the following phase diagram for the next two questions.



What is the normal melting point for this substance? Note: the vertical axis is logarithmic in scale.

1. 150°C

2. 45°C

3. 120°C

4. 20°C

5. 75°C

6. 0°C

003 (part 2 of 2) 10.0 points

A sample of this substance is held at 0.1 atm and −50°C. The sample is pressurized to 3 atm and then heated to 250°C. In total, what phase transitions occurred?

1. melting and boiling

2. sublimation only

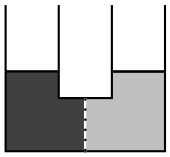
3. sublimation and condensation

4. melting and condensation

5. melting and freezing

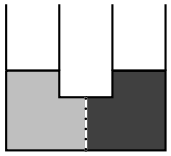
004 10.0 points

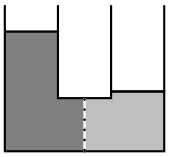
The following diagram shows a solution on the left (dark shade) and just the solvent on the right (light shade) separated by a semipermeable membrane.

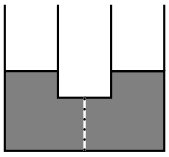


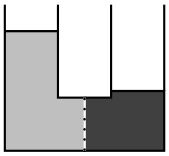
Which diagram best represents the final state of this system after equilibrium is achieved?

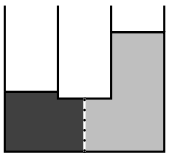
1.



2. 

3. 

4. 

5. 

005 10.0 points

Consider the following substances: acetic acid (CH_3COOH), propane (C_3H_8), and acetone (CH_3COCH_3). The boiling points (in no particular order) are $-42°C$, $56°C$, and $118°C$. The vapor pressures (in no particular order) are 225 Torr, 15 Torr, and 6400 Torr. What is the boiling point and vapor pressure for acetic acid?

1. 118°C, 6400 Torr

2. −42°C, 6400 Torr

3. 56°C, 225 Torr

4. −42°C, 15 Torr

5. 118°C, 15 Torr

006 10.0 points

The enthalpy of vaporization of a liquid is measured to be about 28.4 kJ/mol and its normal boiling point is 128°C. At what temperature is the partial pressure of this substance 1180 torr?

1. -7.92°C

2. 181°C

3. -381°C

4. 176°C

5. 150°C

6. -281°C

7. 162°C

007 10.0 points

A sample of 44.1 g of *para*-dichlorobenzene ($C_6H_4Cl_2$ 147.0 g/mol) is dissolved into 350 mL of hexane (C_6H_{14}, 86.18 g/mol, density 0.661 g/mL). What is the molality of this solution?

1. 1.30 m

2. 0.567 m

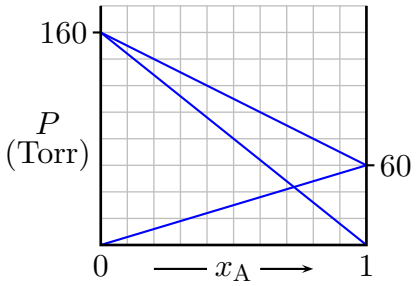
3. 0.101 m

4. 1.17 m

5. 0.857 m

008 10.0 points

A and B are mildly volatile solvents. A mixture is made by combining 2 moles of A with 3 moles of B. Interpret the diagram below to determine the vapor pressure of this mixture.



1. 80 Torr

2. 70 Torr

3. 100 Torr

4. 120 Torr

5. 140 Torr

6. 130 Torr

7. 110 Torr

8. 150 Torr

9. 90 Torr

---

009 10.0 points

Calculate the number of moles of oxygen that will dissolve in 45 L of water at 20°C if the partial pressure of oxygen is 0.21 atm. The Henry's Law constant for oxygen in water at 20°C is 0.0013 M/atm.

1. 0.0013 mol

2. 0.00027 mol

3. 0.28 mol

4. 0.012 mol

5. 0.0062 mol

---

010 10.0 points

A 19.7 g sample of an unknown salt (formula = MX_2) is dissolved in 249.4 mL water. The boiling point of water in this solution is 100.657 °C. What is the molecular weight of the unknown salt?

1. 129.8 g/mol

2. 55.4 g/mol

3. 46.1 g/mol

4. 185 g/mol

5. 61.6 g/mol

---

011 10.0 points

Isocarboxazid (MW = 231.25 g/mol) is an organic monoamine oxidase inhibitor used to treat depression disorders. 38.00 grams of isocarboxazid are added to water to make a 350 mL aqueous solution. What is the osmotic pressure exerted by this solution across a semi-permeable membrane at 37°C?

1. 12.10 atm

2. 329.6 atm

3. 11.95 atm

4. 1.43 atm

5. 144.4 atm

6. 23.90 atm

---

012 10.0 points

Write the equilibrium constant for the following reaction.

$$H_2(g) + Br_2(\ell) \rightleftharpoons 2HBr(g)$$

1. $K_p = \dfrac{P_{HBr}}{P_{H_2}}$

2. $K_p = \dfrac{P_{HBr}^2}{P_{H_2} P_{Br_2}}$

3. $K_p = \dfrac{P_{H_2}}{P_{HBr}^2}$

4. $K_p = \dfrac{P_{HBr}^2}{P_{H_2}[Br_2]}$

5. $K_p = \dfrac{P_{HBr}^2}{P_{H_2}}$

---

013 10.0 points

Consider the following generic gas phase reaction.

$$X_2(g) + 3Y_2(g) \rightleftharpoons 2XY_3(g)$$

The value of K_p for this reaction is 107. Calculate the equilibrium partial pressure of gas

Y_2 if the equilibrium partial pressures of XY_3 is 0.50 atm and X_2 is 0.15 atm?

1. 5.6 atm

2. 0.25 atm

3. 0.016 atm

4. 0.42 atm

5. 0.33 atm

6. 0.031 atm

7. 0.18 atm

---

014 10.0 points

0.834 atm A, 0.565 atm B, and 1.24 atm C are placed into a container to run the following reaction:

$$2A(g) + B(g) \rightleftharpoons 3C(g)$$

At equilibrium, 0.435 atm C remains. What is K_p for this reaction?

1. 0.0526

2. 0.107

3. 0.0230

4. 8.12

5. 18.8

---

015 (part 1 of 2) 10.0 points

Consider the following reaction for the next two questions:

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$$

Beginning at equilibrium, which of the following will result in a shift toward the right of this reaction?

1. Adding CH_3OH gas

2. Adding an inert gas at constant pressure

3. Adding an inert gas at constant volume

4. Removing CO gas

5. Reducing the volume of the container

---

016 (part 2 of 2) 10.0 points

If this reaction is exothermic, lowering the temperature will cause the reaction to...

1. shift right due to a decreased Q value

2. shift left due to a smaller K value

3. shift left due to a smaller Q value

4. shift right due to a larger K value

5. remain at equilibrium

---

017 10.0 points

Calculate the pH of a 0.018 M $Ba(OH)_2$ solution.

1. 8.44

2. 12.26

3. 12.56

4. 5.26

5. 1.44

6. 1.74

---

018 10.0 points

What is the pH of a 0.12 M solution of hydroxylammonium bromide (NH_3OHBr)?

1. 9.56

2. 3.72

3. 3.24

4. 3.61

5. 3.33

6. 4.44

7. 6.04

8. 3.48

---

019 10.0 points

Rank the following acids in increasing order of acidity.

HCN NH_3OH^+ HNO_2 HBrO

1. $NH_3OH^+ < HNO_2 < HBrO < HCN$

2. $NH_3OH^+ < HBrO < HCN < HNO_2$

3. $HCN < NH_3OH^+ < HNO_2 < HBrO$

4. $HCN < HBrO < NH_3OH^+ < HNO_2$

5. $HNO_2 < NH_3OH^+ < HBrO < HCN$

6. $HNO_2 < HBrO < HCN < NH_3OH^+$

---

020 10.0 points

A weak acid, HA, ionizes 7.65% at a 0.250 M concentration. What is the hydroxide ion concentration in this solution?

1. 1.91×10^{-16} M

2. 1.31×10^{-13} M

3. 1.00×10^{-14} M

4. 5.23×10^{-13} M

5. 1.91×10^{-2} M

---

021 10.0 points

What is the pH after 250 mL of 0.25 M HNO_3 is added to 350 mL of 0.50 M CH_3NH_2 (methylamine) ?

1. 10.90

2. 6.21

3. 5.05

4. 3.36

5. 10.64

6. 10.38

7. 3.62

8. 2.29

---

022 10.0 points

What is the ratio of potassium acetate to acetic acid necessary to make a buffer with a pH equal to 5.12?

1. 3.1

2. 2.4

3. 0.38

4. 9.86

5. 0.42

6. 2.9

---

023 10.0 points

What is the dominant species in solution at the equivalence point of a weak base-strong acid titration?

1. Strong base

2. Equal parts weak acid and weak base

3. Weak acid

4. Neutral salt

5. Weak base

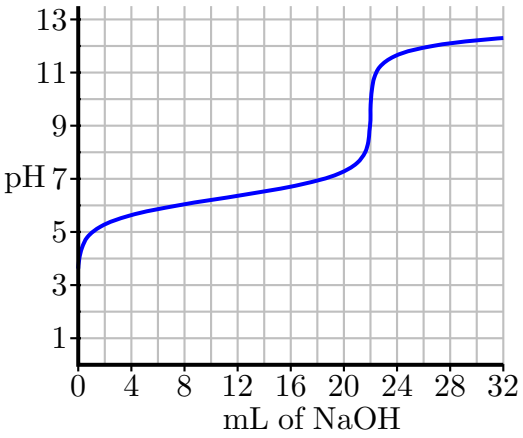
6. Strong acid

---

024 (part 1 of 3) 10.0 points

A sample of 30 mL of a weak acid (HA) so-

lution was titrated with 0.075 M NaOH. The pH curve for this titration is shown.



What is the concentration of the original weak acid solution (the 30 mL) ?

1. 0.032 M

2. 0.022 M

3. 0.055 M

4. 0.075 M

5. 0.048 M

---

025 (part 2 of 3) 10.0 points

Which of the following is the value of K_a for the weak acid, HA ?

1. 1.3×10^{-6}

2. 5.0×10^{-7}

3. 3.2×10^{-10}

4. 1.2×10^{-7}

5. 7.6×10^{-5}

---

026 (part 3 of 3) 10.0 points

Below is a listing of five indicators and their associated pK_a values. Which indicator would be the best one to use for this titration?

1. methyl red, 5.0

2. bromophenol blue, 4.1

3. bromocresol purple, 6.4

4. phenol red, 7.4

5. thymol blue, 9.3

6. alizarin yellow, 10.9

---

027 10.0 points

Which of the following salts is the most soluble in pure water?

1. $BaSO_4$ $K_{sp} = 1.1 \times 10^{-10}$

2. CuBr $K_{sp} = 6.3 \times 10^{-9}$

3. All of these salts have the same solubility

4. CaF_2 $K_{sp} = 3.5 \times 10^{-11}$

---

028 10.0 points

Barium fluoride (BaF_2) is most soluble in which of the following solutions?

1. 0.15 M $Ba(OH)_2$

2. 0.50 M NaF

3. 0.18 M NaF

4. 0.005 M $Ba(OH)_2$

5. The molar solubility of barium fluoride is the same in each of these solutions

---

029 10.0 points

You mix 0.02 mmol $Sr(NO_3)_2$ solution and 0.05 mmol NaF solution to form a 100 mL solution. What precipitate (if any) forms?

1. NaF

2. SrF_2

3. No precipitate forms

4. $Sr(NO_3)_2$

5. $NaNO_3$

---

030 10.0 points

What is the mass of the barium chromate precipitate resulting from the addition of 300 mL 0.025 M $Ba(OH)_2$ to 200 mL 0.040 M Na_2CrO_4?

1. 3.48 g

2. 2.03 g

3. 1.90 g

4. 3.80 g

5. 2.52 g

---

031 10.0 points

Consider the following reaction:

$$2C_2H_6(g) + 7O_2(g) \longrightarrow 4CO_2(g) + 6H_2O(\ell)$$

Oxygen is being consumed at a rate equal to 1.24 M/s. What is the initial rate at which carbon dioxide is forming?

1. 4.96 M/s

2. 8.68 M/s

3. 2.17 M/s

4. 1.24 M/s

5. 0.709 M/s

---

032 (part 1 of 2) 10.0 points

You run an experiment to determine the initial rates of the following generic reaction at various starting conditions:

$$A + X_2 \rightleftharpoons AX_2$$

	[A] M	[X_2] M	initial rate $M \cdot s^{-1}$
Trial 1	0.60	1.56	2.00×10^{-3}
Trial 2	0.60	3.12	8.00×10^{-3}
Trial 3	1.20	1.56	4.00×10^{-3}
Trial 4	0.90	2.40	7.10×10^{-3}

What is the correct rate law for the reaction?

1. Rate = $(1.40)[A]$

2. Rate = $(3.84 \times 10^{-3})[A]^{-1}[X_2]^2$

3. Rate = $(3.84 \times 10^{-3})[A][X_2]^2$

4. Rate = $(1.37 \times 10^{-3})[A][X_2]$

5. Rate = $(1.37 \times 10^{-3})[A][X_2]^2$

---

033 (part 2 of 2) 10.0 points

What are the units of the rate constant in the previous question?

1. $\frac{1}{M^2 \cdot s}$

2. $\frac{1}{M^3 \cdot s}$

3. $\frac{1}{M^4 \cdot s}$

4. $\frac{1}{M \cdot s}$

5. $\frac{M}{s}$

---

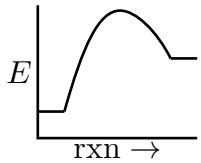
034 10.0 points

The chlorination of methane is an exothermic reaction with a two-step mechanism shown below:

Step 1: $CH_4 + Cl_2 \longrightarrow CH_3 + HCl$ (slow)

Step 2: $CH_3 + Cl_2 \longrightarrow CH_3Cl + Cl^-$ (fast)

Which of the following reaction coordinate diagrams best fits this data?

1.


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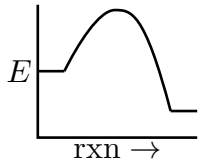

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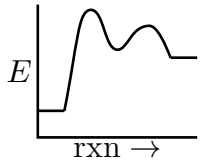

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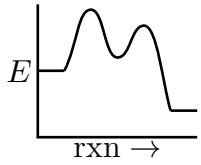

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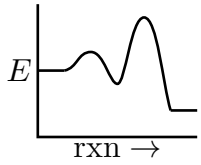

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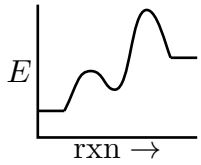

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035 10.0 points

Consider the following overall reaction:

$$2\,A_2 + X \rightarrow B.$$

Using the overall reaction, determine the rate law for the following mechanism:

$A_2 + X \rightleftharpoons Z + Y$ (k_1, fast)

$Z + Y \rightarrow I$ (k_2, slow)

$I + A_2 \rightarrow B$ (k_3, fast)

1. Rate $= k^{'}\,[Z][Y]$

2. Rate $= k^{'}\,[A_2]\,[X]$

3. Rate $= k^{'}\,[A_2]^2\,[X]$

4. Rate $= k^{'}\,[Z]\,[X]$

5. Rate $= k^{'}\,[A_2]^2$

6. Rate $= k^{'}\,[A_2]\,[Z]\,[X]$

---

036 10.0 points

How does a catalyst affect the rate of a chemical reaction?

1. A catalyst increases the energy of the transition state such that a larger number of particles have sufficient energy to overcome the activation energy

2. A catalyst increases the rate constant by providing an alternate mechanism with a lower activation energy

3. A catalyst increases the rate constant by increasing the activation energy

4. A catalyst decreases the rate constant by lowering the activation energy

---

037 10.0 points

$^{99}_{42}$Mo undergoes radioactive decay by emitting a single beta particle. Which of the following reactions corresponds to this process?

1. $^{99}_{42}\mathrm{Mo} \longrightarrow {}^{98}_{42}\mathrm{Tc} + {}^{1}_{0}n$

2. $^{99}_{42}\mathrm{Mo} \longrightarrow {}^{99}_{43}\mathrm{Tc} + {}^{0}_{-1}\beta$

3. $^{99}_{42}\mathrm{Mo} + {}^{0}_{-1}\beta \longrightarrow {}^{99}_{41}\mathrm{Nb}$

4. $^{99}_{42}\mathrm{Mo} + {}^{0}_{-1}\beta \longrightarrow {}^{99}_{43}\mathrm{Tc}$

5. $^{99}_{42}\mathrm{Mo} \longrightarrow {}^{99}_{44}\mathrm{Ru} + {}^{0}_{-1}\beta$

---

038 10.0 points

Identify the missing isotope in the nuclear reaction.

$$^{226}_{88}\mathrm{Ra} \rightarrow \underline{\quad ? \quad} + {}^{4}_{2}\alpha$$

1. $^{230}_{86}$Th

2. $^{230}_{90}$Th

3. $^{222}_{90}$Rn

4. $^{222}_{86}$Rn

5. $^{226}_{86}\mathrm{Rn}$

---

039 10.0 points

$^{123}\mathrm{I}$ is a radioactive isotope ($t_{1/2}$ = 13.22 hours) useful for clinical imaging. How long will it take for a dose to diminish to 18.7% of its original value?

1. 22.2 hours

2. 38.7 hours

3. 557 hours

4. 29.7 hours

5. 87.9 hours

6. 34.2 hours

7. 70.7 hours

8. 32.0 hours

---

040 10.0 points

When direct heat is applied to potassium chlorate, $KClO_3$, it decomposes to form KCl and other byproducts. Was chlorine oxidized or reduced? How many electrons were transferred during the process?

1. oxidized, 6 electrons

2. oxidized, 4 electrons

3. reduced, 9 electrons

4. reduced, 3 electrons

5. reduced, 6 electrons

6. oxidized, 3 electrons

---

041 10.0 points

The following reaction occurs in acidic conditions. What is the coefficient of water in the overall balanced equation? Is it a reactant or a product?

$$As_2O_3 + NO_3^- \longrightarrow H_3AsO_4 + NO$$

1. 7; reactant

2. 3; product

3. 2; product

4. 2; reactant

5. 4; reactant

6. 3; reactant

---

042 (part 1 of 2) 10.0 points

What is the shorthand notation for the following electrochemical cell?

$2Cr^{2+}(aq) + Co^{2+}(aq) \longrightarrow 2Cr^{3+}(aq) + Co(s)$

1. Pt | Cr^{2+} , Cr^{3+} || Co^{2+} | Co

2. Cr^{2+} , Cr^{3+} || Co^{2+} | Co

3. Co | Co^{2+} || Cr^{2+} , Cr^{3+} | Pt

4. Co^{2+} | Co || Cr^{2+} , Cr^{3+}

5. Cr^{2+} | Cr^{3+} || Co^{2+} | Co

---

043 (part 2 of 2) 10.0 points

What is the oxidizing agent in the previous problem?

1. Co

2. Pt

3. Cr^{2+}

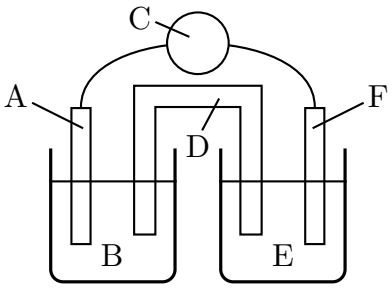
4. Co^{2+}

5. Cr^{3+}

---

044 (part 1 of 2) 10.0 points

The following two questions refer to this diagram for a voltaic cell. Neither of the two electrodes are an inert electrode.



Where would you find the species that is being oxidized?

1. E

2. C

3. B

4. D

5. A

---

045 (part 2 of 2) 10.0 points

If the half-reaction for the anode involves Fe^{2+} and Fe, which of these redox pairs could be in the cell on the right?

1. Mn^{2+} and Mn

2. H^+ and H_2

3. None of these can give a voltaic cell

4. Sn^{2+} and Sn

5. Cr^{3+} and Cr

---

046 10.0 points

Using an electroplating system operating at 7.35 amps, it take 1.50 hours to plate out 5.00 grams of an unknown metal from its molten chloride salt, MCl_2. Identify the metal M.

1. Cu

2. Fe

3. Cd

4. Zn

5. Mg

---

047 10.0 points

Consider a standard voltaic cell at equilibrium. Which of the following is true?

1. $E < 0$, $\Delta G > 0$, $K < 0$

2. $E > 0$, $\Delta G > 0$, $K > 1$

3. $E < 0$, $\Delta G > 0$, $K < 1$

4. $E = 0$, $\Delta G = 0$, $K = 1$

5. $E = 0$, $\Delta G = 0$, $K > 1$

---

048 10.0 points

Consider the following cell:

$$Pd\,|\,Pd^{2+}\,||\,Ru^{3+}\,|\,Ru$$

What is ΔG° for the overall cell reaction that is represented here? Balance the reaction using the lowest possible integer values.

1. −91.2 kJ

2. +182 kJ

3. +877 kJ

4. −182 kJ

5. +91.2 kJ

6. −877 kJ

---

049 10.0 points

Use half-reactions from the standard reduction table to calculate the K_{sp} for $Zn(IO_3)_2$.

1. 1.7×10^{-26}

2. 6.8×10^{-32}

3. 4.8×10^{-12}

4. 3.9×10^{-6}

5. 7.3×10^{-19}

---

050 10.0 points

What is the potential for the following cell?

$\mathrm{In} \,|\, \mathrm{In}^{3+}\,(0.010\,\mathrm{M}) \,||$
$\mathrm{Ce}^{4+}\,(0.50\,\mathrm{M}), \mathrm{Ce}^{3+}\,(0.010\,\mathrm{M}) \,|\, \mathrm{Pt}$

1. 2.37 V

2. 1.95 V

3. 1.81 V

4. 2.02 V

5. 2.09 V

6. 1.88 V