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

001 2.0 points

How many moles are in 63.0 g of $(NH_4)_2Cr_2O_7$?

1. 1.00 mol

2. 4.00 mol

3. 0.500 mol

4. 0.250 mol

002 2.0 points

Consider the combustion of propane (C_3H_8) run at constant temperature and pressure:

$$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$$

If 5.00 L propane is reacted with 30.0 L oxygen, what is the final volume of all gases?

1. 80.0 L

2. 5.00 L

3. 30.0 L

4. 35.0 L

5. 40.0 L

003 2.0 points

A closed tube used to transport methane has a volume of 110 L at 300°C and 965 torr. How many moles of gas are in the tube?

1. 2260

2. 11300

3. 7.78

4. 2.97

5. 22.3

6. 3390

7. 4520

8. 3.89

004 2.0 points

A 2.37 gram gas sample has a volume of 4.35 L, a pressure of 0.8 atm, and a temperature of 304 K. Which of the following gases is it?

1. SF_6

2. CO_2

3. O_2

4. Ne

5. NH_3

6. SO_2

005 2.0 points

The rate of effusion for carbon monoxide (CO) is ____ times the rate of effusion for chlorine (Cl_2) gas .

1. 1.59

2. 2.53

3. 1.16

4. 1.13

5. 2.17

006 2.0 points

Based on the hard sphere model of gases, which of the following gases is best modeled by ideal behavior?

1. He

2. Ar

3. Kr

4. Xe

5. Ne

---

007 2.0 points

The compressibility factor (Z) for a gas at 400 atm is less than one. How can you make an accurate gas law calculation for this gas at 400 atm?

1. This gas can be modeled ideally at this pressure because $PV > nRT$

2. You must correct for attractive forces because $PV > nRT$

3. This gas can be modeled ideally at this pressure because $PV < nRT$

4. You must correct for repulsive forces because $PV < nRT$

5. This gas can be modeled ideally at this pressure because $PV = nRT$

6. You must correct for attractive forces because $PV < nRT$

7. You must correct for repulsive forces because $PV > nRT$

---

008 2.0 points

Consider three closed 10L containers at room temperature. Container 1 contains 0.5 moles neon gas. Container 2 contains 0.5 moles argon gas. Container 3 contains 0.5 moles hydrogen gas. Which of the following properties, if any, are the same between the containers?

I. Mass density

II. Number density

III. Kinetic energy

IV. Pressure

1. III only

2. I and III only

3. I, II, III and IV

4. None of the above

5. I only

6. II and IV only

7. I and IV only

8. II, III, and IV only

---

009 2.0 points

Consider the following balanced chemical reaction:

$$2\text{HOCl(g)} \rightarrow 2\text{HCl(g)} + \text{O}_2\text{(g)}$$

At a certain temperature, 98.2 grams of hypochlorous acid (HOCl) fully decomposes to give a final pressure of 680 torr. What is the partial pressure of oxygen in the final reaction system?

1. 680 torr

2. 1223 torr

3. 1020 torr

4. 340 torr

5. 227 torr

---

010 2.0 points

Consider the van der Waals equation for non ideal gases. Which of the following statements is true?

1. A gas with a low molecular weight will have a high a value

2. $(P + \frac{an^2}{V^2})$ represents the measured pressure

3. This equation can only be used to model

ideal gases

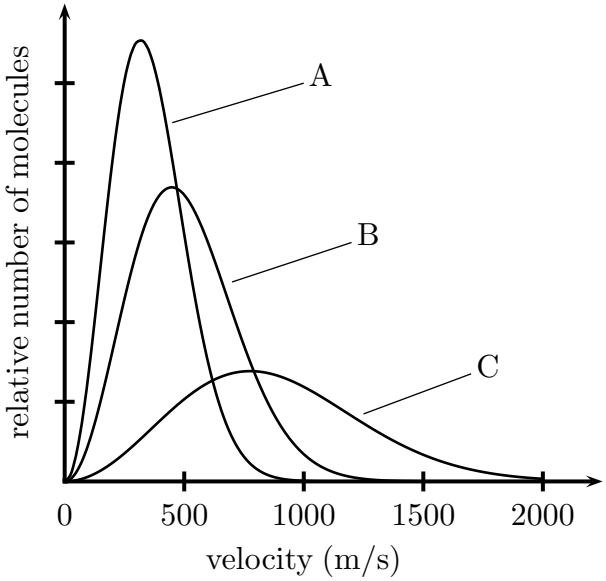
4. A large b value correlates with a low molecular weight

5. The b term correlates with the size of particles in a gaseous system

---

011 2.0 points

The graph shows the approximate Maxwell-Boltzmann distribution plots for three different gases at the same temperature.



Which of the following statements is true?

1. The gas with the lowest molecular weight is Gas C

2. Gas B is heavier than Gas A

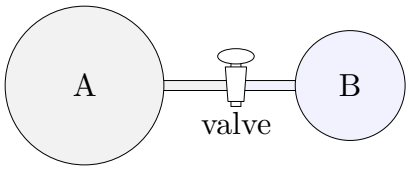
3. Gas C has the greatest kinetic energy

4. The v_{rms} for Gas A is 1500 m/s

---

012 2.0 points

Consider the diagram shown below of two glass bulbs connected through a valve. The volume for each gas (A and B) is shown under the bulbs and the gases also happen to be at the same temperature (337K) and pressure (713 torr).



After the valve is opened, the two gases mix completely. What is the partial pressure of gas A in this new (opened valve) state?

1. 713 torr

2. 250.9 torr

3. 185.6 torr

4. 2026 torr

5. 527.4 torr

---

013 2.0 points

What is the wavelength of a 4.50 $\times 10^{14}$ Hz light ray?

1. 882 nm

2. 666 nm

3. 0.288 nm

4. 456 nm

5. 0.882 nm

6. 992 nm

7. 0.441 nm

8. 0.664 nm

---

014 2.0 points

A 200 nm beam of light is shined on a gold surface. What is the maximum velocity of the excited electrons? The work function of gold is 5.10 eV.

1. 4.406×10^5 km/s

2. 3.883×10^8 km/s

3. -440.6 km/s

4. 440.6 km/s

5. 408.2 km/s

6. No electrons are emitted

7. 623.2 km/s

---

015 2.0 points

When a cold gas absorbs white light, you see a continuous absorption spectrum broken by thin black lines in the blue and purple region. Which of the following best describes the emission spectrum of this gas when it is excited with electricity?

1. A continous spectrum broken by black lines shifted to slightly longer wavelengths

2. Mostly black with thin lines in the blue and purple region

3. Mostly black with thin lines in the yellow and orange region

4. A continuous spectrum broken by black lines in the yellow and orange region

---

016 2.0 points

An excited hydrogen electron emits a photon in the Balmer series when it falls from $n = 5$. What is the energy of the photon emitted?

1. 4.58×10^{-19} J

2. 2.3×10^{6} J

3. 4.58×10^{-17} J

4. -2.3×10^{-17} J

5. -4.58×10^{-17} J

6. 2.3×10^{-17} J

---

017 2.0 points

Which set of quantum numbers is possible for an electron in the s subshell found in the ground state of Se?

1. $n = 3, \ell = 2, m_\ell = +2, m_s = +\frac{1}{2}$

2. $n = 4, \ell = 4, m_\ell = +2, m_s = +\frac{1}{2}$

3. $n = 4, \ell = 2, m_\ell = +1, m_s = -\frac{1}{2}$

4. $n = 4, \ell = 1, m_\ell = +1, m_s = -\frac{1}{2}$

5. $n = 4, \ell = 0, m_\ell = 0, m_s = +\frac{1}{2}$

6. $n = 1, \ell = 1, m_\ell = +2, m_s = -\frac{1}{2}$

---

018 2.0 points

A fellow student completes an electron filling diagram for a ground state atom as shown below:

$3d$ $\underline{\uparrow\downarrow}$ ___ ___ ___ ___
$3s$ $\underline{\uparrow\downarrow}$
$2p$ $\underline{\uparrow\downarrow}$ ___ ___
$2s$ $\underline{\uparrow\downarrow}$
$1s$ $\underline{\uparrow\downarrow}$

Understanding that your fellow student's electron filling diagram is not necessarily correct (*i.e.*, the electrons have not necessarily been placed in the correct orbitals), what is the electron configuration for this atom?

1. $1s^1 2s^1 2p^3 3s^1 3d^4$

2. $1s^2 2s^2 2p^3 3s^2 3d^1$

3. $1s^2 2s^2 2p^6 3s^2$

4. $1s^2 2s^2 2p^2 3s^2 3d^2$

5. $1s^2 2s^2 2p^6$

---

019 2.0 points

The second ionization energy of Ti is given by the reaction:

$$Ti^{+}(g) \longrightarrow Ti^{2+}(g) + e^{-}$$

This electron is removed from the:

1. 4d subshell

2. 4p subshell

3. 3d subshell

4. 3p subshell

5. 3s subshell

6. 4s subshell

---

020 2.0 points

Rank the following ionic compounds from least to greatest lattice energy:

K_2O, MgO, $CaCO_3$, KCl

1. $KCl < K_2O < MgO < CaCO_3$

2. $CaCO_3 < K_2O < MgO < KCl$

3. $KCl < K_2O < CaCO_3 < MgO$

4. $CaCO_3 < K_2O < KCl < MgO$

5. $MgO < KCl < K_2O < CaCO_3$

---

021 2.0 points

Consider the following molecules:

CO, CO_2, CO_3^{2-}

Which molecule has the strongest covalent bonds?

1. Both CO_3^{2-} and CO_2 have the strongest bonds

2. CO_2

3. All carbon-oxygen bonds have the same strength bonds

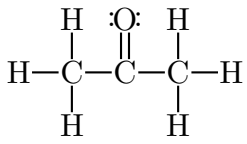
4. CO

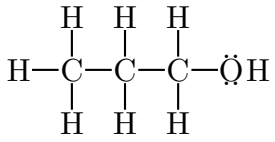
5. CO_3^{2-}

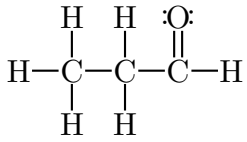
---

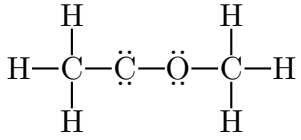
022 2.0 points

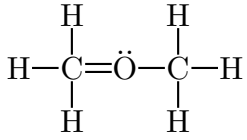
Which of the following choices is the correct line structure for acetone, CH_3COCH_3?

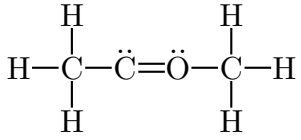
1.


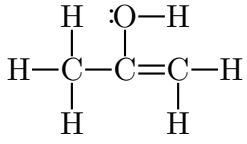
2.


3.


4.


5.


6.


7.


---

023 2.0 points

In an acceptable Lewis structure for NO_2^{-}, what is the formal charge on the central atom?

1. -2

2. +2

3. -1

4. +1

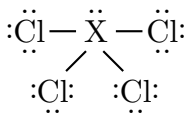
5. None of the above

6. 0

---

024 2.0 points

Consider the following molecule:



What is the identify of the central atom, X?

1. Nitrogen

2. Carbon

3. Oxygen

4. Chlorine

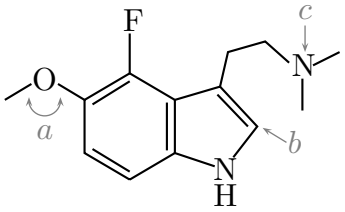
5. Phosphorus

6. Selenium

---

025 (part 1 of 3) 2.0 points

The molecule shown below is a rare alkaloid found in plants native to South America with profound cultural significance.



What is the correct empirical formula for this compound?

1. $C_{13}H_{12}FN_2O$

2. $C_{15}H_{17}FN_2O$

3. $C_{13}H_{17}FN_2O$

4. $C_{13}H_{19}FN_2O$

5. $C_{13}H_{19}N_2O$

6. $C_{12}H_{15}FN_2O$

---

026 (part 2 of 3) 2.0 points

Which of the following best represents the bond angle labeled a?

1. 178°

2. 118°

3. 109.5°

4. 120°

5. 180°

6. 90°

7. 104.5°

---

027 (part 3 of 3) 2.0 points

What is the electronic geometry around the central atom labeled b?

1. Tetrahedral

2. Trigonal planar

3. Bent

4. Trigonal pyramid

5. Seesaw

---

028 2.0 points

VSEPR theory can estimate imperfect bond angles based on the fact that

1. bonding regions attract each other while lone pair regions repel each other

2. molecular orbitals hybridize

3. bonding regions are more repulsive than lone pair regions

4. lone pair regions are more repulsive than

bonding regions

029 2.0 points

Which of the following molecules is non-polar?

1. $BeCl_2$

2. H_2O

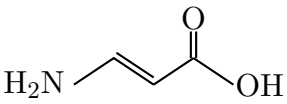
3. PCl_3

4. HBr

5. NH_3

030 (part 1 of 2) 2.0 points

Use the following structure to answer the next two questions:



How many sigma and pi bonds are in the organic structure above?

1. 12 σ only

2. 10 σ and 2 π

3. 8 σ and 2 π

4. 12 σ and 2 π

5. 10 σ and 4 π

031 (part 2 of 2) 2.0 points

For the structure shown above, what is the hybridization around the nitrogen?

1. sp^2

2. sp

3. sp^3

4. sp^3d

5. sp^3d^2

032 2.0 points

Consider the MO diagram for F_2^+. What is the bond order? Is F_2^+ paramagnetic or diamagnetic?

1. 1, diamagnetic

2. 2, diamagnetic

3. 2, paramagnetic

4. 1.5, diamagnetic

5. 1.5, paramagnetic

6. 2.5, diamagnetic

7. 2.5, paramagnetic

033 2.0 points

Rank the following substances in order of vapor pressure: Cl_2, I_2, Br_2, F_2

1. $Br_2 < Cl_2 < I_2 < F_2$

2. $I_2 < Br_2 < Cl_2 < F_2$

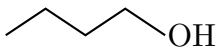
3. $F_2 < Cl_2 < I_2 < Br_2$

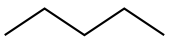
4. $I_2 < F_2 < Cl_2 < Br_2$

5. $F_2 < Cl_2 < Br_2 < I_2$

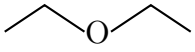
034 2.0 points

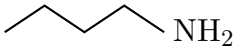
Which of the following has the lowest vapor pressure?

1. 

2. 

3. 

4. 

5. 

---

035 2.0 points

Which of the following can form hydrogen bonds with another molecule of itself?

I. Ammonia

II. Ethanol

III. CH_3OCH_3

IV. H_2CO

1. I, II only

2. I only

3. I, II, III, IV

4. I, III, IV only

---

036 2.0 points

Select the option that correctly lists the substances in order of INCREASING boiling points.

1. O_2, C_2H_6, C_3H_8, NH_3, H_2O, NaCl, CaO

2. O_2, C_3H_8, C_2H_6, NH_3, H_2O, NaCl, CaO

3. None of these places the substances in correct order of increasing boiling points

4. O_2, NH_3, C_2H_6, C_3H_8, H_2O, CaO, NaCl

5. O_2, NH_3, C_3H_8, C_2H_6, NaCl, CaO, H_2O

---

037 2.0 points

Name the bond in oxygen (O_2) that forms as a result of head-on overlap on the internuclear axis.

1. σ_{2p-2p}

2. $\pi_{sp^2-sp^2}$

3. σ_{sp-sp^2}

4. π_{2p-2p}

5. σ_{sp-sp}

6. $\sigma_{sp^2-sp^2}$

7. $\pi_{sp^3-sp^3}$

8. σ_{sp^2-2p}

---

038 2.0 points

Arrange the following substances in order from highest to lowest melting point:

C(s, diamond), NH_3, LiF, $CaSO_4$

1. C(s, diamond) > $CaSO_4$ > NH_3 > LiF

2. C(s, diamond) > $CaSO_4$ > LiF > NH_3

3. NH_3 > LiF > $CaSO_4$ > C(s, diamond)

4. C(s, diamond) > LiF > $CaSO_4$ > NH_3

5. NH_3 > $CaSO_4$ > LiF > C(s, diamond)

---

039 2.0 points

Which of the following terms is path-dependent?

1. Work

2. Heat Capacity

3. Free Energy

4. Enthalpy

5. All of the above

---

040 2.0 points

A chemical reaction releases 86.9 kJ heat while 16.7 kJ work is done on the system via compression. What is the change in the internal energy (ΔU) for the system?

1. 104 kJ

2. -70.2 kJ

3. -109 kJ

4. -75.2 kJ

5. -53.5 kJ

6. -104 kJ

---

041 2.0 points

When an endothermic reaction has a positive internal energy change for the system,

I. the internal energy change of the system is equal to the heat plus the work

II. $\Delta H_{\text{rxn}} > 0$

III. there is an overall energy change in the universe

IV. heat enters the system from the surroundings

1. I only

2. I and IV only

3. I, II, III and IV

4. I, II, and IV only

5. I and II only

6. II only

7. III and IV only

---

042 2.0 points

For which of the following reactions is $\Delta U_{\text{sys}} < \Delta H_{\text{sys}}$ at constant external pressure?

1. $2NH_3(g) \rightarrow 3H_2(g) + N_2(g)$

2. $C_2H_4(g) + 3O_2(g) \rightarrow 2CO_2(g) + 2H_2O(l)$

3. $SnO_2(g) + C(s) \rightarrow Sn(s) + CO_2(g)$

4. $N_2(g) + O_2(g) \rightarrow 2NO(g)$

5. $N_2O_5(l) + H_2O(l) \rightarrow 2HNO_3(aq)$

---

043 2.0 points

A 21 mL sample of liquid water at 39°C is frozen and cooled to a final temperature of -18°C. Calculate the heat of this process.

1. −11230 J

2. 10440 J

3. -7804 J

4. -534.8 J

5. 11230 J

---

044 2.0 points

When a 0.401 g sample of a clean-burning hydrocarbon (molecular weight = 42.05 g/mol) is combusted in a rigid container, the temperature increases from 24.987°C to 28.623°C. The total volume of water is 0.746 L. The sum of all hardware components of the calorimeter have a heat capacity of 2.24 kJ/°C. Calculate the internal energy of combustion for one mole of this hydrocarbon.

1. -19.4936 kJ/mol

2. +8150.74 kJ/mol

3. +48.6124 kJ/mol

4. -2044.15 kJ/mol

5. +2044.15 kJ/mol

6. -3.26600 kJ/mol

7. +19.4936 kJ/mol

8. +3.26600 kJ/mol

---

045 2.0 points

Carbon dioxide is a unique substance that sublimes at atmospheric pressure. Assuming no excess heat is supplied to the system at constant pressure, what are the signs of ΔH, ΔS, and w for the following phase change reaction at -78.5°C?

$$CO_2(s) \rightarrow CO_2(g)$$

1. $\Delta H > 0, \Delta S > 0, w > 0$

2. $\Delta H > 0, \Delta S > 0, w = 0$

3. $\Delta H > 0, \Delta S > 0, w < 0$

4. $\Delta H > 0, \Delta S < 0, w < 0$

5. $\Delta H < 0, \Delta S < 0, w = 0$

---

046 2.0 points

For which of the following chemical equations would $\Delta H^\circ_{rxn} = \Delta H^\circ_f$?

1. $\frac{1}{2}N_2(g) + \frac{3}{2}H_2(g) \rightarrow NH_3(g)$

2. $CH_4(g) + 2Cl_2(g) \rightarrow CCl_4(\ell) + 2H_2(g)$

3. $N_2(\ell) + 3Cl_2(g) \rightarrow 2NCl_3(\ell)$

4. $2C(s, \text{graphite}) + O_2(\ell) \rightarrow 2CO(g)$

5. $CH_4(g) \rightarrow C(s, \text{graphite}) + 2H_2(g)$

---

047 2.0 points

Consider the following balanced chemical reaction:

$$H_2SO_4(l) \rightarrow SO_3(g) + H_2O(g)$$

To solve for the ΔH°_{rxn} for this reaction, you collect the following data in the lab:

$H_2S(g) + 2O_2(g) \rightarrow H_2SO_4(l)$,

$\Delta H^\circ_{rxn} = \text{-232.3 kJ/mol}$

$H_2S(g) + 2O_2(g) \rightarrow SO_3(g) + H_2O(l)$,

$\Delta H^\circ_{rxn} = \text{-201.1 kJ/mol}$

$H_2O(l) \rightarrow H_2O(g)$,

$\Delta H^\circ_{rxn} = 51.9 \text{ kJ/mol}$

What is the ΔH°_{rxn} of the overall balanced reaction?

1. 485 kJ/mol

2. -614 kJ/mol

3. 315 kJ/mol

4. -382 kJ/mol

5. 83.1 kJ/mol

---

048 2.0 points

Use bond energy data to determine ΔH_{rxn} for the following reaction:

$CH_4 + 2Cl_2 \rightarrow CCl_4 + 2H_2$

1. -45 kJ/mol

2. 45 kJ/mol

3. -90 kJ/mol

4. 90 kJ/mol

5. −180 kJ/mol

---

049 2.0 points

Calculate the ΔS_{surr} for the following reaction at 9.0°C and 1 atm.

$CH_3F(\ell) \rightarrow CH_3F(g) \quad \Delta H^\circ_{rxn} = +16.9 \text{ kJ}$

1. 1.88 J/K

2. -939 J/K

3. 59.9 J/K

4. -59.9 J/K

5. 1880 J/K

6. -1.88 J/K

---

050 2.0 points

Consider a reaction that has a negative change in entropy and a positive change in enthalpy. Which of the following conditions will favor spontaneity?

1. This reaction is spontaneous at all temperatures

2. Low Temperatures

3. High Temperatures

4. This reaction is non-spontaneous at all temperatures