Your Name: _____   Your ID: _____

Question #: 1

Samples of $CO_2(g)$, $C_6H_6(g)$, $Cl_2(g)$ and $C_3H_8(g)$ are placed in separate glass vessels (only one gas to a vessel) at the same temperature and pressure. The gas that effuses through a hole in the vessel into a vacuum with the slowest speed is _____.

   A. $CO_2(g)$
   B. $C_6H_6(g)$
   C. $Cl_2(g)$
   D. $C_3H_8(g)$

Question #: 2

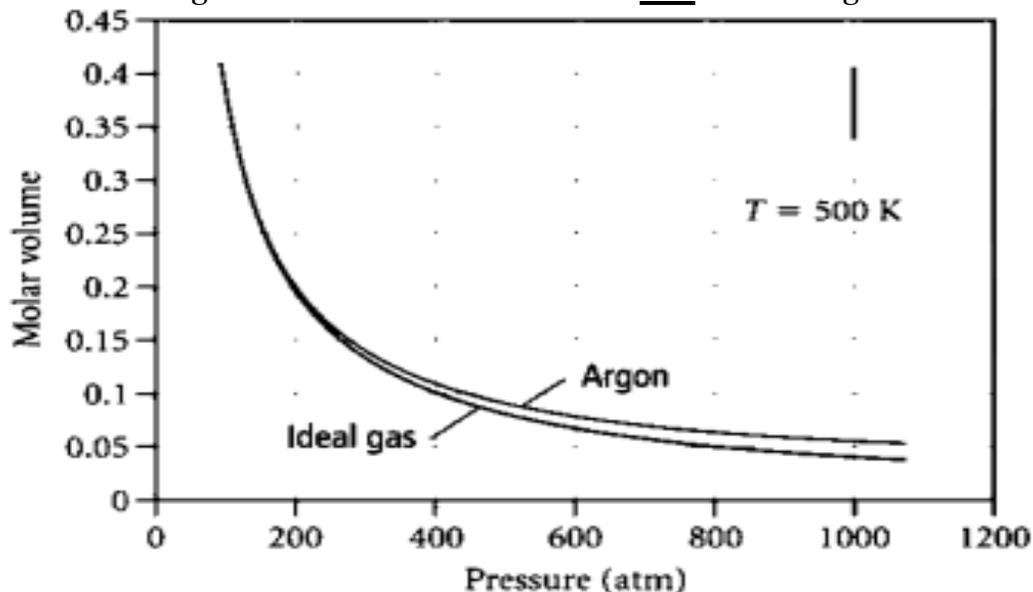The curves in the graph below represent the velocity distributions of the same molecule at different temperatures.
Which curve corresponds to the lowest temperature?

   A. A
   B. B
   C. C
   D. D

Consider the figure below. Which statement is **true** concerning the behavior of argon gas?

A. Argon has a higher molar volume at lower pressure than an ideal gas.

B. Argon has a higher molar volume at higher pressure than an ideal gas.

C. The molar volume of gases are not effected by pressure.

D. Lower pressures result in higher deviations from ideal gas behavior than higher pressures.

Question #: 4

Which statement is true of the internal energy of the system and its surroundings following a process in which $\Delta E_{sys} = +100kJ$?

A. The system and surroundings both lose 100 kJ of energy.

B. The system and surroundings both gain 100 kJ of energy.

C. The system loses 100 kJ and the surroundings gain 100 kJ of energy.

D. The system gains 100 kJ and the surroundings lose 100 kJ of energy.

Question #: 5

Which of the following states the first law of thermodynamics?

    A. Energy can be created and destroyed.
    B. Energy can be destroyed but not created.
    C. Energy cannot be created or destroyed.
    D. Energy cannot be converted from one form to another.

Question #: 6

A chemical reaction releases heat and produces a net increase in the volume of gas. If the chemical reaction is the system, what are the signs of heat (q) and work (w) for the system?

    A. q = +, w = +
    B. q = −, w = −
    C. q = −, w = +
    D. q = +, w = −

Question #: 7

If a system absorbs 325 J of energy from the surroundings while it does 92.0 J of work, what is the change in internal energy of the system?
Report your answer with **three** significant figures. Do **NOT** include units in your answer.
  1   J

    1. _____

How much heat is required to raise the temperature of 155 g of copper metal from 33.00°C to 75.00°C?
The specific heat capacity of copper is 0.385 J/g•°C.

    A. 16.2 kJ
    B. 2.51×10^3 J
    C. 2.60×10^3 kJ
    D. 6.44×10^3 J

Which statement is **false**?

    A. An exothermic reaction releases heat to the surroundings.
    B. Enthalpy is the sum of a system's internal energy and the product of pressure and volume under constant-pressure conditions.
    C. The change in internal energy for a reaction is not related to the change in enthalpy of the reaction.
    D. The change in enthalpy for a reaction can be measured using a coffee-cup calorimeter.

A 100.0 g iron bar, initially at 58.35 °C, is submerged in 125 g of water, initially at 25.00 °C, in an insulated container.
What is the final temperature of both substances at thermal equilibrium?
The specific heat capacity of iron is 0.449 J/g•°C and the specific heat capacity of water is 4.18 J/g•°C.
Report your answer with **three** significant figures.   Do **NOT** include units in your answer.
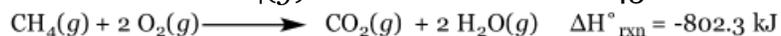 1   °C

    1. _____

What mass of $CH_4(g)$ must burn to release 452 kJ of heat?

$CH_4(g) + 2 O_2(g) \longrightarrow CO_2(g) + 2 H_2O(g) \quad \Delta H°_{rxn} = -802.3$ kJ

A. 9.04 g
B. 4.60 g
C. 28.0 g
D. 11.7 g

When 0.514 g of biphenyl ($C_{12}H_{10}$) undergoes comubustion in a bomb calorimeter, the temperature increases from 25.80 °C to 29.40 °C. If the heat capacity of the bomb calorimeter is 5.86 kJ/°C, what is the change in internal energy of the combustion of biphenyl in kJ? Report your answer with **two** significant figures. Report your answer in **scientific notation** with the format 2.2E2 or 2.2E-2. Do **NOT** include units in your answer.
The first blank should include only the sign (+ or –). The second blank should include only a number **without** a sign.
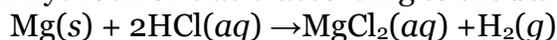   1   indicate + or –
    2   kJ

    1. _____
    2. _____

For which **two** of the following reactions is the change in enthalpy equal to the change in internal energy?

A. $C(s) + O_2(g) \rightarrow CO_2(g)$
B. $2 H_2O(l) \rightarrow 2 H_2(g) + O_2(g)$
C. $4 C_3H_5N_3O_9(l) \rightarrow 12 CO_2(g) + 10 H_2O(g) + 6 N_2(g) + O_2(g)$
D. $N_2O_4(g) + 4 H_2(g) \rightarrow N_2(g) + 4 H_2O(g)$
E. $2 C_8H_{18}(l) + 25 O_2(g) \rightarrow 18 H_2O(g) + 16 CO_2(g)$

Magnesium metal reacts with hydrochloric acid according to the balanced equation below:

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

When 0.254 g of Mg metal is completely reacted with enough $HCl(aq)$ to produce 2.00×10^2 mL of solution in a constant-pressure calorimeter, the temperature of the solution was observed to rise from 25.00°C to 32.20°C. What is the **change in enthalpy for the reaction** (as written) **per mole of Mg(s)**? Use 1.00 g/mL for the density of the solution, and 4.18 J/g•°C for the specific heat capacity of the solution.
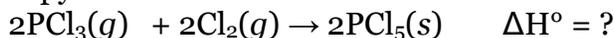
A. +6.02×10³ kJ/mol
B. -5.76×10⁵ J/mol
C. +7.64 J/mol
D. -73.2 kJ/mol

Consider the following reaction.

$$PCl_5(s) \rightarrow PCl_3(g) + Cl_2(g) \qquad \Delta H° = +157 \text{ kJ}$$

What is the change in enthlalpy for the reaction below?

$$2PCl_3(g) + 2Cl_2(g) \rightarrow 2PCl_5(s) \qquad \Delta H° = ?$$

A. +157 kJ
B. −2.46×10⁴ kJ
C. −314 kJ
D. +78.5 kJ

Consider the following reactions.

$CH_2CO(g) + 2 O_2(g) \rightarrow 2 CO_2(g) + H_2O(g) \qquad \Delta H = -981.1 \text{ kJ}$
$CH_4(g) + 2 O_2(g) \rightarrow CO_2(g) + 2 H_2O(g) \qquad \Delta H = -802.3 \text{ kJ}$

Find the enthalpy change for the reaction below.

$CH_2CO(g) + 3 H_2O(g) \rightarrow 2 CH_4(g) + 2 O_2(g)$

A. 623.5 kJ
B. 1783.6 kJ
C. −178.8 kJ
D. −1293.0 kJ

Given the following data, calculate the enthalpy of formation of $CCl_4(g)$.

$CH_4(g) + 4\ Cl_2(g) \rightarrow CCl_4(g) + 4\ HCl(g)$ $\Delta H° = -391$ kJ

$\Delta H°_f$ of $CH_4(g) = -74.6$ kJ/mol

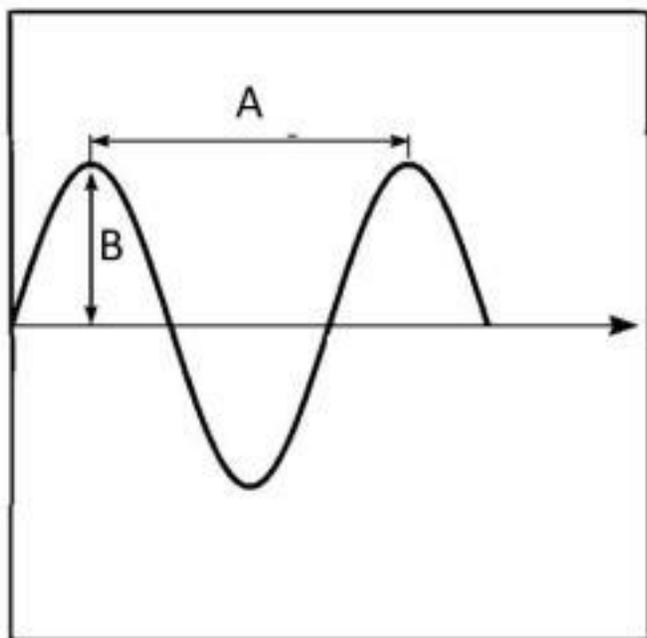$\Delta H°_f$ of $CCl_4(g) = \underline{\ \ 1\ \ }$ kJ/mol

$\Delta H°_f$ of $HCl(g) = -92.3$ kJ/mol

Report your answer with **three** significant figures.   Do **NOT** include units in your answer.

1. _____

In the figure below, **A** is the __1__ of a wave and **B** is the __2__ of a wave.   Choose between **amplitude, wavelength, and frequency.**

1. _____
2. _____

Select the option that lists the types of electromagnetic radiation from longest to shortest **wavelength**.

    A. radiowaves >infrared >orange light >blue light >ultraviolet >gamma rays
    B. gamma rays >ultraviolet >blue light >orange light >infrared >radiowaves
    C. gamma rays >infrared >orange light >blue light >ultraviolet >radiowaves
    D. ultraviolet >blue light >orange light >gamma rays >infrared >radiowaves

---

Strontium salts are used in red fireworks, emitting light with a wavelegnth of 635 nm. What is the frequency of the emitted light?
Report your answer with **three** significant figures. Use the format 2.22E2 or 2.22E-2 for scientific notation.   Do **NOT** include units in your answer.
  1   Hz

    1. _____

What is the energy of the orange light emitted, per photon, by a neon sign with a frequency of 4.89×10^{14} Hz?
Report your answer   with **three** significant figures in scientific notation with the format 2.22E2 or 2.22E-2.   Do **NOT** include units in your answer.
  1   J/photon

    1. _____

The longest wavelength of light capable of removing an electron from a metal sample is 68.1 nm. What is the kinetic energy of an electron ejected when the sample is irradiated with light of wavelength 50.0 nm?

    A. 1.06×10^{-18} J
    B. 0 J
    C. 637 J
    D. 3.45×10^{-27} J

_____

Which of the following statements is **<u>true</u>** about the atomic spectra of elements?

    A. The absorption spectrum of an element consists of a pattern of colored lines.
    B. The emission spectrum of an element consists of a pattern of dark lines.
    C. The emission spectrum of an element consists of a pattern of colored lines.
    D. Different wavelengths of light are absorbed in absorption spectroscopy than the wavelengths of light emitted in emission spectroscopy

_____

Calculate the de Broglie wavelength (nm) of a hydrogen atom traveling at 475 m/s. The mass of a hydrogen atom is 1.67×10^{-24} g.
   1   nm
Report your answer with **two** significant figures.   Use the format 2.2E2 or 2.2E-2 for scientific notation.   Do **NOT** include units in your answer.

    1. _____

_____

An electron moving at a velocity of 6.25×10^6 m/s has an uncertainty in its speed of 2.21×10^5 m/s. What is the minimum uncertainty (in nm) in the electron's position? The mass of an electron is 9.11×10^{-31} kg.
Report your answer with **three** significant figures. Do **NOT** include units in your answer.   Use the format 2.22E2 or 2.22E-2 for scientific notation.
  __1__ nm

1. _____

Fill in the blanks (1-4) with A, B, C, **or** D.   Use each letter only **once**.
  __1__ principal quantum number   A. m_s
  __2__ angular momentum quantum number   B. has possible values of $-l$ to $+l$
  __3__ magnetic quantum number   C. determines the size of an orbital
  __4__ spin quantum number   D. has letter designations of s, p, d, f

1. _____
2. _____
3. _____
4. _____

What is the wavelength, in nm, of the photon emitted when an electron in a hydrogen atom undergoes a transition from the $n=3$ level to the $n=2$ level?
Report your answer with **three** significant figures.   Do **NOT** include units in your answer.
  __1__ nm

1. _____

Which **two** of the following sets of quantum numbers, [n, l, m_l], are allowed for an electron in an atom?

    A. [1, 0, 0]
    B. [3, 4, −4]
    C. [3, 2, −2]
    D. [1, 0, 1]

What is the angular momentum quantum number (l) of an electron in a $5f$ subshell of an atom?

    A. 1
    B. 2
    C. 3
    D. 4

The ΔH of one mole of carbon-hydrogen bonds is 414 kJ/mol.   What is the longest wavelength of light, in nm, with enough energy to break a single carbon-hydrogen bond?
  _1_   nm
Report your answer with **three** significant figures. Use the format 2.22E2 or 2.22E-2 for scientific notation.   Do **NOT** include units in your answer.

    1. _____

CHE 105 Fall 2016 Exam 3 - Confidential

Your Name: _____   Your ID: _____

Periodic Table of the Elements

Molar volume of ideal gas at STP = 22.4 L
Faraday constant, $F = 9.6485 \times 10^4$ C/mol e
Avogadro's number, $N = 6.022 \times 10^{23}$ mol^{-1}
Planck's constant, $h = 6.626 \times 10^{-34}$ J·s

Ideal gas constant:
$R = 8.314$ J·K^{-1}·mol^{-1}
$R = 1.987$ cal·K^{-1}·mol^{-1}
$R = 8.206 \times 10^{-2}$ L·atm·K^{-1}·mol^{-1}

Speed of light, $c = 3.00 \times 10^8$ m·s^{-1}
Rydberg constant, $R_H = 2.18 \times 10^{-18}$ J
Electron charge, $e = 1.602 \times 10^{-19}$ C
Atomic mass unit, $u = 1.6605 \times 10^{-24}$ g

attachment_for_pubExamUID_lnxp114787018186032988XX_137.jpg

Question #: 1

Samples of $CO_2(g)$, $C_6H_6(g)$, $Cl_2(g)$ and $C_3H_8(g)$ are placed in separate glass vessels (only one gas to a vessel) at the same temperature and pressure. The gas that effuses through a hole in the vessel into a vacuum with the slowest speed is _____.

    A. $CO_2(g)$
  ✓B. $C_6H_6(g)$
    C. $Cl_2(g)$
    D. $C_3H_8(g)$

Question #: 2

The curves in the graph below represent the velocity distributions of the same molecule at different temperatures.

Which curve corresponds to the lowest temperature?
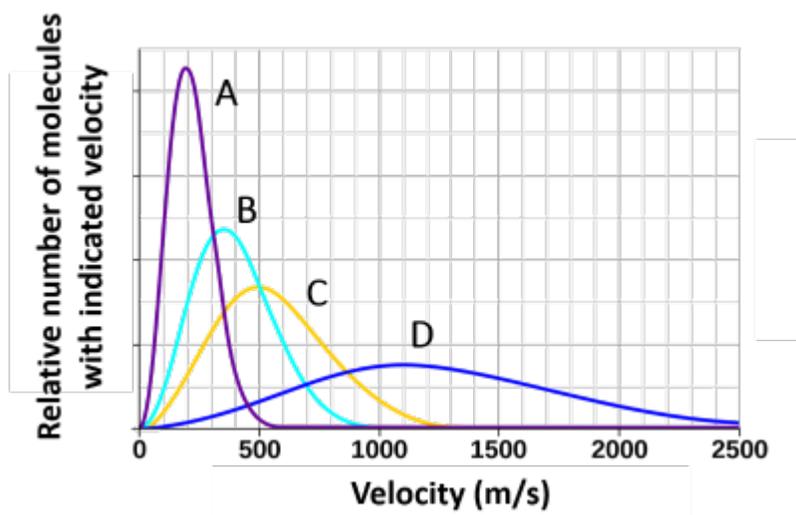
✓A. A
   B. B
   C. C
   D. D

Question #: 3

Consider the figure below. Which statement is **true** concerning the behavior of argon gas?
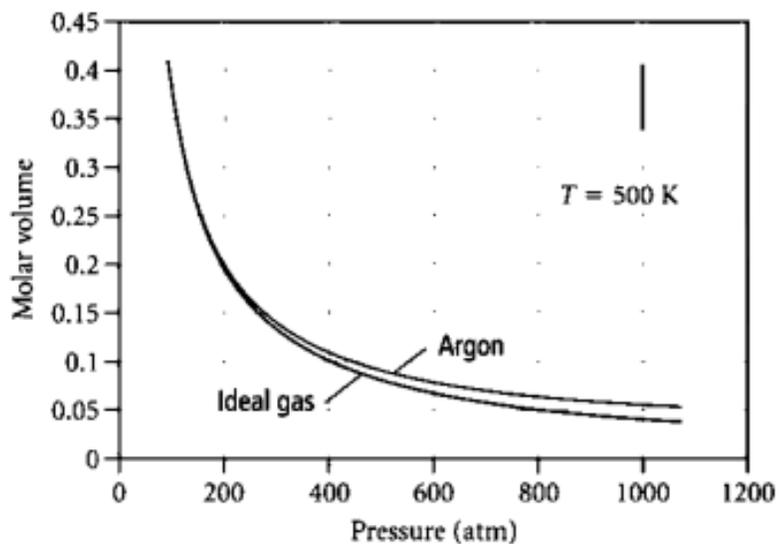
A. Argon has a higher molar volume at lower pressure than an ideal gas.

✓B. Argon has a higher molar volume at higher pressure than an ideal gas.

C. The molar volume of gases are not effected by pressure.

D. Lower pressures result in higher deviations from ideal gas behavior than higher pressures.

Question #: 4

Which statement is true of the internal energy of the system and its surroundings following a process in which ΔE_{sys} = +100kJ?

A. The system and surroundings both lose 100 kJ of energy.

B. The system and surroundings both gain 100 kJ of energy.

C. The system loses 100 kJ and the surroundings gain 100 kJ of energy.

✓D. The system gains 100 kJ and the surroundings lose 100 kJ of energy.

Question #: 5

Which of the following states the first law of thermodynamics?

A. Energy can be created and destroyed.

B. Energy can be destroyed but not created.

✓C. Energy cannot be created or destroyed.

D. Energy cannot be converted from one form to another.

Question #: 6

A chemical reaction releases heat and produces a net increase in the volume of gas. If the chemical reaction is the system, what are the signs of heat (q) and work (w) for the system?

A. q = +, w = +

✓B. q = −, w = −

C. q = −, w = +

D. q = +, w = −

If a system absorbs 325 J of energy from the surroundings while it does 92.0 J of work, what is the change in internal energy of the system?

Report your answer with **three** significant figures. Do **NOT** include units in your answer.

___1___ J

1. 233|+233|

How much heat is required to raise the temperature of 155 g of copper metal from 33.00ºC to 75.00ºC?

The specific heat capacity of copper is 0.385 J/g•ºC.

A. 16.2 kJ
✓B. 2.51×10^3 J
C. 2.60×10^3 kJ
D. 6.44×10^3 J

Which statement is **false**?

A. An exothermic reaction releases heat to the surroundings.
B. Enthalpy is the sum of a system's internal energy and the product of pressure and volume under constant-pressure conditions.
✓C. The change in internal energy for a reaction is not related to the change in enthalpy of the reaction.
D. The change in enthalpy for a reaction can be measured using a coffee-cup calorimeter.

A 100.0 g iron bar, initially at 58.35 ºC, is submerged in 125 g of water, initially at 25.00 ºC, in an insulated container.

What is the final temperature of both substances at thermal equilibrium?

The specific heat capacity of iron is 0.449 J/g•°C and the specific heat capacity of water is 4.18 J/g•°C.

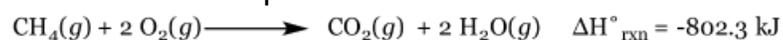Report your answer with **three** significant figures. Do **NOT** include units in your answer.

____1____ °C

   1. <u>27.7</u>

Question #: 11

What mass of $CH_4(g)$ must burn to release 452 kJ of heat?

$CH_4(g) + 2\ O_2(g) \longrightarrow CO_2(g) + 2\ H_2O(g)\quad \Delta H^\circ_{rxn} = \text{-802.3 kJ}$

  ✓A. 9.04 g
    B. 4.60 g
    C. 28.0 g
    D. 11.7 g

Question #: 12

When 0.514 g of biphenyl ($C_{12}H_{10}$) undergoes comubustion in a bomb calorimeter, the temperature increases from 25.80 °C to 29.40 °C. If the heat capacity of the bomb calorimeter is 5.86 kJ/°C, what is the change in internal energy of the combustion of biphenyl in kJ?

Report your answer with **two** significant figures. Report your answer in **scientific notation** with the format 2.2E2 or 2.2E-2. Do **NOT** include units in your answer.

The first blank should include only the sign (+ or −). The second blank should include only a number **without** a sign.

____1____ indicate + or −

____2____ kJ

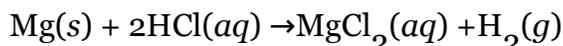   1. <u>-|negative|minus|</u>
   2. <u>6.3e3|6.2e3|6.1e3|</u>

For which **two** of the following reactions is the change in enthalpy equal to the change in internal energy?

  ✓A. $C(s) + O_2(g) \rightarrow CO_2(g)$
   B. $2\ H_2O(l) \rightarrow 2\ H_2(g) + O_2(g)$
   C. $4\ C_3H_5N_3O_9(l) \rightarrow 12\ CO_2(g) + 10\ H_2O(g) + 6\ N_2(g) + O_2(g)$
  ✓D. $N_2O_4(g) + 4\ H_2(g) \rightarrow N_2(g) + 4\ H_2O(g)$
   E. $2\ C_8H_{18}(l) + 25\ O_2(g) \rightarrow 18\ H_2O(g) + 16\ CO_2(g)$

Magnesium metal reacts with hydrochloric acid according to the balanced equation below:
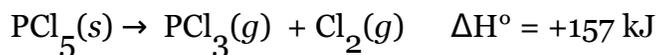$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$
When 0.254 g of Mg metal is completely reacted with enough HCl(aq) to produce 2.00×10^2 mL of solution in a constant-pressure calorimeter, the temperature of the solution was observed to rise from 25.00°C to 32.20°C. What is the **change in enthalpy for the reaction** (as written) **per mole of Mg(s)**? Use 1.00 g/mL for the density of the solution, and 4.18 J/g•°C for the specific heat capacity of the solution.

   A. $+6.02 \times 10^3$ kJ/mol
  ✓B. -5.76×10^5 J/mol
   C. $+7.64$ J/mol
   D. -73.2 kJ/mol

Consider the following reaction.
$$PCl_5(s) \rightarrow PCl_3(g) + Cl_2(g) \qquad \Delta H° = +157\ kJ$$
What is the change in enthlalpy for the reaction below?
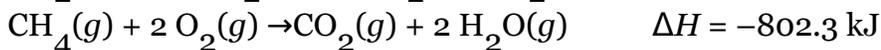$$2PCl_3(g) + 2Cl_2(g) \rightarrow 2PCl_5(s) \qquad \Delta H° = ?$$

   A. $+157$ kJ

B. -2.46×10^4 kJ

✓C. -314 kJ

D. $+78.5$ kJ

Question #: 16

Consider the following reactions.

$CH_2CO(g) + 2\ O_2(g) \rightarrow 2\ CO_2(g) + H_2O(g)$ $\Delta H = -981.1$ kJ

$CH_4(g) + 2\ O_2(g) \rightarrow CO_2(g) + 2\ H_2O(g)$ $\Delta H = -802.3$ kJ

Find the enthalpy change for the reaction below.

$CH_2CO(g) + 3\ H_2O(g) \rightarrow 2\ CH_4(g) + 2\ O_2(g)$
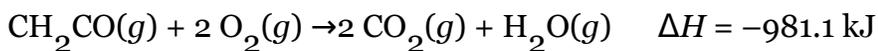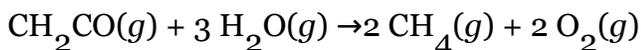
✓A. 623.5 kJ

B. 1783.6 kJ

C. -178.8 kJ

D. -1293.0 kJ

Question #: 17

Given the following data, calculate the enthalpy of formation of $CCl_4(g)$.
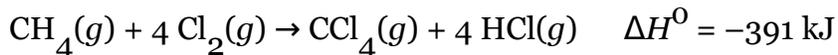
    $CH_4(g) + 4\ Cl_2(g) \rightarrow CCl_4(g) + 4\ HCl(g)$ $\Delta H^O = -391$ kJ

ΔH^O_f of $CH_4(g) = -74.6$ kJ/mol

ΔH^O_f of $CCl_4(g) =$ ___1___ kJ/mol

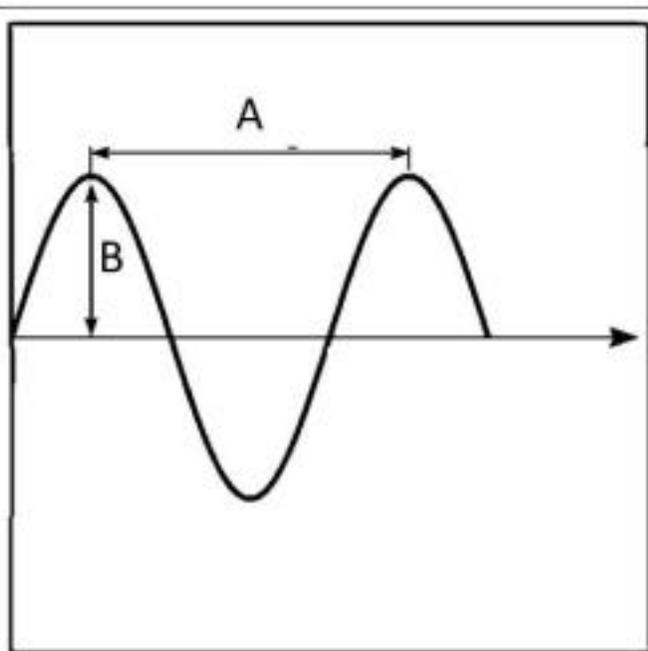ΔH^O_f of $HCl(g) = -92.3$ kJ/mol

Report your answer with **three** significant figures. Do **NOT** include units in your answer.

    1. -96.4|-9.64E1|-9.64e1|

Question #: 18

In the figure below, **A** is the ___1___ of a wave and **B** is the ___2___ of a wave. Choose between **amplitude, wavelength, and frequency.**

1. Wave Length|wavelength|
2. Amplitude

Question #: 19

Select the option that lists the types of electromagnetic radiation from longest to shortest **wavelength**.

  ✓A. radiowaves >infrared >orange light >blue light >ultraviolet >gamma rays
    B. gamma rays >ultraviolet >blue light >orange light >infrared >radiowaves
    C. gamma rays >infrared >orange light >blue light >ultraviolet >radiowaves
    D. ultraviolet >blue light >orange light >gamma rays >infrared >radiowaves

---

Question #: 20

Strontium salts are used in red fireworks, emitting light with a wavelegnth of 635 nm. What is the frequency of the emitted light?

Report your answer with **three** significant figures. Use the format 2.22E2 or 2.22E-2 for scientific notation. Do **NOT** include units in your answer.

  __1__ Hz

1. 4.72E14|4.72e14|

What is the energy of the orange light emitted, per photon, by a neon sign with a frequency of 4.89×10^{14} Hz?

Report your answer   with **three** significant figures in scientific notation with the format 2.22E2 or 2.22E-2. Do **NOT** include units in your answer.

  1   J/photon

1. 3.24E-19

The longest wavelength of light capable of removing an electron from a metal sample is 68.1 nm. What is the kinetic energy of an electron ejected when the sample is irradiated with light of wavelength 50.0 nm?

✓A. 1.06×10^{-18} J

B. 0 J

C. 637 J

D. 3.45×10^{-27} J

Which of the following statements is **true** about the atomic spectra of elements?

A. The absorption spectrum of an element consists of a pattern of colored lines.

B. The emission spectrum of an element consists of a pattern of dark lines.

✓C. The emission spectrum of an element consists of a pattern of colored lines.

D. Different wavelengths of light are absorbed in absorption spectroscopy than the wavelengths of light emitted in emission spectroscopy

Question #: 24

Calculate the de Broglie wavelength (nm) of a hydrogen atom traveling at 475 m/s. The mass of a hydrogen atom is 1.67×10^{-24} g.

___1___ nm

Report your answer with **two** significant figures. Use the format 2.2E2 or 2.2E-2 for scientific notation. Do **NOT** include units in your answer.

    1. .83|.82|.84|8.3e-1|8.2e-1|8.4e-1|0.83|0.82|0.84|

Question #: 25

An electron moving at a velocity of 6.25×10^6 m/s has an uncertainty in its speed of 2.21×10^5 m/s. What is the minimum uncertainty (in nm) in the electron's position? The mass of an electron is 9.11×10^{-31} kg.

Report your answer with **three** significant figures. Do **NOT** include units in your answer. Use the format 2.22E2 or 2.22E-2 for scientific notation.

___1___ nm

    1. 0.262|2.62E-1|2.62e-1|.262|

Question #: 26

Fill in the blanks (1-4) with A, B, C, **or** D. Use each letter only **once**.

___1___ principal quantum number	A. m_s
___2___ angular momentum quantum number	B. has possible values of $-l$ to $+l$
___3___ magnetic quantum number	C. determines the size of an orbital
___4___ spin quantum number	D. has letter designations of s, p, d, f

    1. C|c|C.|c.|
    2. D|d|D.|d.|
    3. B|b|B.|b.|
    4. A|a|A.|a.|

Question #: 27

What is the wavelength, in nm, of the photon emitted when an electron in a hydrogen atom undergoes a transition from the $n=3$ level to the $n=2$ level?

Report your answer with **three** significant figures. Do **NOT** include units in your answer.

___1___ nm

    1. 657

Question #: 28

Which **two** of the following sets of quantum numbers, $[n, l, m_l]$, are allowed for an electron in an atom?

  ✓A. $[1, 0, 0]$
    B. $[3, 4, -4]$
  ✓C. $[3, 2, -2]$
    D. $[1, 0, 1]$

Question #: 29

What is the angular momentum quantum number (l) of an electron in a $5f$ subshell of an atom?

    A. 1
    B. 2
  ✓C. 3
    D. 4

Question #: 30

The ΔH of one mole of carbon-hydrogen bonds is 414 kJ/mol. What is the longest wavelength of light, in nm, with enough energy to break a single carbon-hydrogen bond?

___1___ nm

Report your answer with **three** significant figures. Use the format 2.22E2 or 2.22E-2 for scientific notation. Do **NOT** include units in your answer.

1. 2.89e2|2.88e2|2.90e2|289|288|290|