Consider the image below, then fill in the blanks with the supplied terms.

In this image, the molecular orbitals A and B are formed by ___1___ [s, p, or d] atomic orbitals. A is ___2___ [bonding, antibonding] molecular orbital. B is formed by is formed by ___3___ [constructive, destructive] interference. The molecular orbital labeled ___4___ [A, B] has higher energy.

1. __________
2. __________
3. __________
4. __________
Select the image of the bonding molecular orbital for the mixing of the two $2p_x$ orbitals (end-to-end) as represented below.
A certain homonuclear, diatomic ion has 10 valence electrons. Use the molecular orbital energy level diagram below to calculate the bond order.
Bond order = __1__  Report your answer as a whole number.

1. __________
Question #: 4

Scroll down to see the image of the energy levels of valence molecular orbitals. Determine the molecular orbital diagram for O₂. Then select the true statement concerning the \( \pi_{2p} \) sublevel.
A. There are no electrons in the \( \pi_{2p}^* \) sublevel. The molecule is diamagnetic.

B. There are two valence electrons in the \( \pi_{2p}^* \) sublevel. The molecule is diamagnetic.

C. There are two valence electrons in the \( \pi_{2p}^* \) sublevel. The molecule is paramagnetic.

D. There are four valence electrons in the \( \pi_{2p}^* \) sublevel. The molecule is paramagnetic.

---

**Question #:** 5

The resonance structure for \( \text{O}_3 \) is

![Resonance structure for O₃](image)

What is represented in the image below for \( \text{O}_3 \)?

![MO structure for O₃](image)
A. delocalized molecular orbital
B. one π2p orbital
C. four πbonds
D. two πbonds.

**Question #**: 6

Energy is ___________. The SI unit for energy is ______________.

A. the capacity to do work; calorie
B. work; calorie
C. the capacity to do work; joule
D. work; joule

**Question #**: 7

Fill in the blanks with kinetic energy, potential energy or thermal energy.

1. ______ is the energy produced by a moving object.
2. ______ is the energy associated with the random motion on the molecular level.

1. __________
2. __________

**Question #**: 8

Chemical energy is a type of 1 ______ [kinetic, potential] energy. The chemical energy can be released and converted to 2 ______ [thermal, solar] energy during the course of a chemical reaction.

1. __________
2. __________
Question #: 9

Select the property that is **NOT** a state function

A. Enthalpy  
B. Heat  
C. Volume  
D. Amplitude

Question #: 10

___1___ is the transfer of thermal energy.

   1. _________

Question #: 11

Select the **false** statement.

A. Specific heat capacity is the energy required to raise the temperature of one gram of a substance by one degree Celsius.  
B. Specific heat capacity times mass is heat capacity.  
C. Heat can be obtained by multiplying heat capacity by the change in temperature.  
D. Heat, specific heat capacity and heat capacity are all different names for the same property of a substance.

Question #: 12

In an internal combustion engine (such as a gasoline powered automobile), the spark causes the combustion of the fuel and an expansion of the produced gas to lift the piston. Select the **two** true statements.

A. The heat of the combustion process has a negative sign.  
B. The heat of the combustion process has a positive sign.  
C. The work produced by the combustion process has a negative sign.  
D. The work produced by the combustion process has a positive sign.
Question #: 13

Choose the correct phrase. When heat is transferred between the system and the surroundings,

A. the heat of the system is equal in magnitude but opposite in sign to the heat of the surroundings.
B. the heat of the system is equal to the heat of the surroundings in both magnitude and sign.
C. the heat of the system is twice the magnitude as the heat of the surroundings.
D. the heat of the system is twice the magnitude as the heat of the surroundings, but opposite in sign.

Question #: 14

Calculate the heat, in kJ, of a 1.2 kg piece of iron that is cooled from 175.0 °C to 32.0 °C. The specific heat capacity of iron is 0.444 J/g °C.

\[1 \text{ kJ}\]

Report your answer with two significant figures. Do NOT include units in your answer. For numbers in scientific notation, use the format 2.22E2 or 2.22E-2.

1. _________

Question #: 15

A gas expands from 100. mL to 950. mL against an external pressure of 2.00 atm. Calculate the work of the system in joules. 101.3 J = 1 L·atm.

\[1 \text{ J}\]

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

1. _________
**Question #**: 16

The change in energy of a system can be determined by

A. adding heat and work.
B. subtracting work from heat.
C. multiplying work and heat.
D. subtracting heat from work.

**Question #**: 17

A baby’s ventilator reduces the volume of air, requiring 70 J of work and requires an additional 0.25 kJ of thermal energy to heat the air. By how much did the internal energy, in kJ of the air (the system) change?

A. +0.32 kJ
B. +71 kJ
C. +0.18 kJ
D. −0.18 kJ
Question #: 18

Consider the energy diagram for the conversion of mercury(II) oxide to mercury and oxygen. Select the true statement.

A. The process is endothermic; energy is absorbed from the surroundings.
B. The process is endothermic; energy is given off to the surroundings.
C. The process is exothermic; energy is absorbed from the surroundings.
D. The process is exothermic; energy is given off to the surroundings.

Question #: 19

Given
\[ \text{CaCO}_3(s) \rightarrow \text{CaO} (s) + \text{CO}_2(g) \quad \Delta H = 178 \text{ kJ} \]

What is the enthalpy change (\(\Delta H\)) for the reaction below?
\[ 2\text{CaO}(s) + 2\text{CO}_2(g) \rightarrow 2\text{CaCO}_3(s) \]

\(1\) kJ

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

1. __________
Question #: 20

The oxidation of Cu₂O to CuO is described by the thermochemical equation below.

\[ 2 \text{Cu}_2\text{O(s)} + \text{O}_2(\text{g}) \rightarrow 4 \text{CuO(s)} \quad \Delta H = -292 \text{kJ} \]

The reaction, as written is **endothermic**. Calculate the heat produced (in kJ) when 5.00 grams of Cu₂O (molar mass = 143.09 g/mol) undergoes the oxidation reaction.

\[
2 \text{kJ} \]

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

1. __________
2. __________

Question #: 21

A 5.00-gram sample of NH₄NO₃ is dissolved in water in a constant pressure calorimeter with a total heat capacity of 2.830 kJ/°C and the temperature decreases by 0.560 °C. Calculate the molar heat of solution of NH₄NO₃ in kJ/mol. The molar mass of NH₄NO₃ is 80.06 g/mol.

A. 25.4 kJ/mol
   B. 32.6 kJ/mol
   C. 14.2 kJ/mol
   D. 21.1 kJ/mol
Question #: 22

Select the two true statements about the image provided.

A. The image is a schematic of a constant volume calorimeter.
B. The apparatus is used for solution reactions.
C. The image is a schematic of a constant pressure calorimeter.
D. The apparatus is used for combustion reactions.

Question #: 23

For reactions that take place in constant ________ environments, the enthalpy change is synonymous with the heat change. It is ________________ for endothermic reactions and ________________ for exothermic reactions.

A. pressure; positive; negative
B. pressure; negative; positive
C. volume; positive; negative
D. volume; negative; positive
Question #: 24

From the equations and standard enthalpies of reaction given below, what is $\Delta H^\circ_{\text{rxn}}$ for the reaction:

$$4 \text{HF}(g) + \text{O}_2(g) \rightarrow 2 \text{F}_2(g) + 2 \text{H}_2\text{O}(l) \quad \Delta H^\circ_{\text{rxn}} = ?$$

Given:

$$\text{F}_2(g) + \text{H}_2(g) \rightarrow 2 \text{HF}(g) \quad \Delta H^\circ_{\text{rxn}} = -537 \text{ kJ}$$

$$2 \text{H}_2(g) + \text{O}_2(g) \rightarrow 2 \text{H}_2\text{O}(l) \quad \Delta H^\circ_{\text{rxn}} = -572 \text{ kJ}$$


A. 394 kJ
B. 502 kJ
C. $-1583$ kJ
D. 1142 kJ
E. $-993$ kJ

---

Question #: 25

The enthalpy of formation, $\Delta H^\circ_f$, of potassium bromide (KBr) = $-392$ kJ/mol. Which reaction is the formation reaction of KBr and corresponds to this energy value?

A. $2 \text{K}(s) + \text{Br}_2(g) \rightarrow 2 \text{KBr}(s)$
B. $\text{K}(s) + 1/2 \text{Br}_2(g) \rightarrow \text{KBr}(s)$
C. $\text{KBr}(s) \rightarrow \text{K}(s) + 1/2 \text{Br}_2(g)$
D. $\text{K}^+(g) + \text{Br}^-(g) \rightarrow \text{KBr}(s)$
Question #: 26

From the information provided, what is the standard enthalpy of formation, $\Delta H^o_f$, for IF(g)?  

\[ \text{IF}_7(g) + \text{I}_2(g) \rightarrow \text{IF}_5(g) + 2 \text{IF}(g) \quad \Delta H^o_{\text{rxn}} = -89 \text{ kJ} \]

<table>
<thead>
<tr>
<th>Substance</th>
<th>$\Delta H^o_f$</th>
</tr>
</thead>
<tbody>
<tr>
<td>IF$_7$(g)</td>
<td>-941 kJ/mol</td>
</tr>
<tr>
<td>IF$_5$(g)</td>
<td>-840 kJ/mol</td>
</tr>
</tbody>
</table>

A. 24 kJ/mol  
B. 101 kJ/mol  
C. -95 kJ/mol  
D. -146 kJ/mol  
E. -191 kJ/mol

---

Question #: 27

Given the following data, calculate the enthalpy of formation of H$_2$O(l).

\[ 2 \text{H}_3\text{BO}_3(s) + 6 \text{H}_2(g) \rightarrow \text{B}_2\text{H}_6(g) + 6 \text{H}_2\text{O}(l) \quad \Delta H^o = 510 \text{ kJ} \]

$\Delta H^o_f$ of H$_3$BO$_3$(s) = -1094 kJ/mol  
$\Delta H^o_f$ of B$_2$H$_6$(g) = 38 kJ/mol  
$\Delta H^o_f$ of H$_2$O(l) = ___ kJ/mol

Report your answer with three significant figures. Do NOT include units in your answer. Do NOT use scientific notation.

1. ______

---

Question #: 28

**Bonus Question**

A maximum of ___ grams of CO$_2$ can be produced from the reaction of 105 grams of CH$_3$OH with 61 grams of O$_2$.

\[ 2 \text{CH}_3\text{OH}(l) + 3 \text{O}_2(g) \rightarrow 2 \text{CO}_2(g) + 4 \text{H}_2\text{O}(l) \]

Report your answer with two significant figures. Do NOT include units in your answer. Do NOT use scientific notation.

1. ______
Consider the image below, then fill in the blanks with the supplied terms.
In this image, the molecular orbitals A and B are formed by _1_ [s, p, or d] atomic orbitals. A is a _2_ [bonding, antibonding] molecular orbital. B is formed by _3_ [constructive, destructive] interference. The molecular orbital labeled _4_ [A, B] has higher energy.

1. s
2. bonding
3. destructive
4. B

**Question #: 2**

Select the image of the bonding molecular orbital for the mixing of the two-2p_x orbitals (end-to-end) as represented below.

A.  

B.  

✓C.  

D.
A certain homonuclear, diatomic ion has 10 valence electrons. Use the molecular orbital energy level diagram below to calculate the bond order.

Bond order = 1

Report your answer as a whole number.
Scroll down to see the image of the energy levels of valence molecular orbitals. Determine the molecular orbital diagram for O₂⁻.
Then select the true statement concerning the sublevel.

\[ \pi_{2p}^* \]

A. There are no electrons in the \[ \pi_{2p}^* \] sublevel. The molecule is diamagnetic.
B. There are two valence electrons in the
sublevel. The molecule is diamagnetic.

✓ C. There are two valence electrons in the

\[ \pi^*_{2p} \]

sublevel. The molecule is paramagnetic.

D. There are four valence electrons in the

\[ \pi^*_{2p} \]

sublevel. The molecule is paramagnetic.

---

**Question #: 5**

The resonance structure for \( \text{O}_3 \) is

What is represented in the image below for \( \text{O}_3 \)?

✓ A. delocalized molecular orbital

B. one \( \pi_{2p} \) orbital

C. four \( \pi \) bonds

D. two \( \pi \) bonds.
Question #: 6

Energy is ___________. The SI unit for energy is ______________.

A. the capacity to do work; calorie
B. work; calorie
C. the capacity to do work; joule
D. work; joule

Question #: 7

Fill in the blanks with kinetic energy, potential energy or thermal energy.

1. ________ is the energy produced by a moving object.
2. ________ is the energy associated with the random motion on the molecular level.

1. kinetic energy|kinetic|
2. thermal energy|thermal|

Question #: 8

Chemical energy is a type of ________ [kinetic, potential] energy. The chemical energy can be released and converted to ________ [thermal, solar] energy during the course of a chemical reaction.

1. potential
2. thermal

Question #: 9

Select the property that is **NOT** a state function

A. Enthalpy
B. Heat
C. Volume
D. Amplitude
Question #: 10

1 is the transfer of thermal energy.

1. heat

Question #: 11

Select the false statement.

A. Specific heat capacity is the energy required to raise the temperature of one gram of a substance by one degree Celsius.
B. Specific heat capacity times mass is heat capacity.
C. Heat can be obtained by multiplying heat capacity by the change in temperature.
[D. Heat, specific heat capacity and heat capacity are all different names for the same property of a substance.]

Question #: 12

In an internal combustion engine (such as a gasoline powered automobile), the spark causes the combustion of the fuel and an expansion of the produced gas to lift the piston. Select the two true statements.

[A. The heat of the combustion process has a negative sign.
B. The heat of the combustion process has a positive sign.
[C. The work produced by the combustion process has a negative sign.
D. The work produced by the combustion process has a positive sign.]

Question #: 13

Choose the correct phrase. When heat is transferred between the system and the surroundings,

[A. the heat of the system is equal in magnitude but opposite in sign to the heat of the surroundings.
B. the heat of the system is equal to the heat of the surroundings in both magnitude and sign.
C. the heat of the system is twice the magnitude as the heat of the surroundings.]
D. the heat of the system is twice the magnitude as the heat of the surroundings, but opposite in sign.

**Question #: 14**

Calculate the heat, in kJ, of a 1.2 kg piece of iron that is cooled from 175.0 °C to 32.0 °C. The specific heat capacity of iron is 0.444 J/g·°C.

\[
\text{Heat} = \frac{1}{\text{specific heat capacity}} \times (\text{mass} \times (\text{final temperature} - \text{initial temperature}))
\]

\[
\text{Heat} = \frac{1}{0.444 \text{ J/g·°C}} \times (1.2 \text{ kg} \times (32 \text{ °C} - 175 \text{ °C}))
\]

\[
= \frac{1000 \text{ g}}{0.444 \text{ J/g·°C}} \times (32 \text{ °C} - 175 \text{ °C})
\]

\[
= \frac{1000 \text{ g}}{0.444 \text{ J/g·°C}} \times (-143 \text{ °C})
\]

\[
\approx -76 \text{ kJ}
\]

Report your answer with two significant figures. Do NOT include units in your answer. For numbers in scientific notation, use the format 2.22E2 or 2.22E-2.

1. -76

**Question #: 15**

A gas expands from 100. mL to 950. mL against an external pressure of 2.00 atm. Calculate the work of the system in joules. 101.3 J = 1 L·atm.

\[
\text{Work} = \frac{1}{101.3} \times (\text{initial volume} - \text{final volume}) \times \text{pressure}
\]

\[
\text{Work} = \frac{1}{101.3} \times (100 \text{ mL} - 950 \text{ mL}) \times 2 \text{ atm}
\]

\[
\approx \frac{1}{101.3} \times (-850 \text{ mL}) \times 2 \text{ atm}
\]

\[
\approx -172 \text{ J}
\]

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

1. 172

**Question #: 16**

The change in energy of a system can be determined by

- A. adding heat and work.
- B. subtracting work from heat.
- C. multiplying work and heat.
- D. subtracting heat from work.

**Question #: 17**
A baby’s ventilator reduces the volume of air, requiring 70 J of work and requires an additional 0.25 kJ of thermal energy to heat the air. By how much did the internal energy, in kJ of the air (the system) change?

A. +0.32 kJ
B. +71 kJ
C. +0.18 kJ
D. −0.18 kJ

Consider the energy diagram for the conversion of mercury(II) oxide to mercury and oxygen. Select the true statement.

✓A. The process is endothermic; energy is absorbed from the surroundings.
B. The process is endothermic; energy is given off to the surroundings.
C. The process is exothermic; energy is absorbed from the surroundings.
D. The process is exothermic; energy is given off to the surroundings.
**Question #**: 19

Given

\[ \text{CaCO}_3(s) \rightarrow \text{CaO} (s) + \text{CO}_2(g) \quad \Delta H = 178 \text{ kJ} \]

What is the enthalpy change (\(\Delta H\)) for the reaction below?

\[ 2\text{CaO}(s) + 2\text{CO}_2(g) \rightarrow 2\text{CaCO}_3(s) \]

1 kJ

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

1. -356

**Question #**: 20

The oxidation of Cu\(_2\)O to CuO is described by the thermochemical equation below.

\[ 2 \text{Cu}_2\text{O}(s) + \text{O}_2(g) \rightarrow 4 \text{CuO}(s) \quad \Delta H = -292 \text{ kJ} \]

The reaction, as written is 1 exothermic, endothermic.

Calculate the heat produced (in kJ) when 5.00 grams of Cu\(_2\)O (molar mass = 143.09 g/mol) undergoes the oxidation reaction.

2 kJ

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

1. exothermic
2. 5.10E-5.10

**Question #**: 21

A 5.00-gram sample of NH\(_4\)NO\(_3\) is dissolved in water in a constant pressure calorimeter with a total heat capacity of 2.830 kJ/°C and the temperature decreases by 0.560 °C.

Calculate the molar heat of solution of NH\(_4\)NO\(_3\) in kJ/mol. The molar mass of NH\(_4\)NO\(_3\) is 80.06 g/mol.

✓ A. 25.4 kJ/mol
   
   B. 32.6 kJ/mol
Question #: 22

Select the **two** true statements about the image provided.

- ✔ A. The image is a schematic of a constant volume calorimeter.
- B. The apparatus is used for solution reactions.
- C. The image is a schematic of a constant pressure calorimeter.
- ✔ D. The apparatus is used for combustion reactions.

Question #: 23

For reactions that take place in constant ________ environments, the enthalpy change is synonymous with the heat change. It is ________________ for endothermic reactions and ________________ for exothermic reactions.

- ✔ A. pressure; positive; negative
- B. pressure; negative; positive
- C. volume; positive; negative
- D. volume; negative; positive

Question #: 24
From the equations and standard enthalpies of reaction given below, what is $\Delta H^\circ_{\text{rxn}}$ for the reaction:

$$4 \text{HF(g)} + \text{O}_2(g) \rightarrow 2 \text{F}_2(g) + 2 \text{H}_2\text{O(l)} \quad \Delta H^\circ_{\text{rxn}} = ?$$

Given:

$$\text{F}_2(g) + \text{H}_2(g) \rightarrow 2 \text{HF(g)} \quad \Delta H^\circ_{\text{rxn}} = -537 \text{ kJ}$$

$$2 \text{H}_2(g) + \text{O}_2(g) \rightarrow 2 \text{H}_2\text{O(l)} \quad \Delta H^\circ_{\text{rxn}} = -572 \text{ kJ}$$

A. 394 kJ
B. 502 kJ
C. $-1583$ kJ
D. 1142 kJ
E. $-993$ kJ

---

**Question # 25**

The enthalpy of formation, $\Delta H^\circ_f$, of potassium bromide (KBr) = $-392$ kJ/mol. Which reaction is the formation reaction of KBr and corresponds to this energy value?

A. $2 \text{K(s)} + \text{Br}_2(g) \rightarrow 2 \text{KBr(s)}$
B. $\text{K(s)} + 1/2 \text{Br}_2(g) \rightarrow \text{KBr(s)}$
C. $\text{KBr(s)} \rightarrow \text{K(s)} + 1/2 \text{Br}_2(g)$
D. $\text{K}^+(g) + \text{Br}^-(g) \rightarrow \text{KBr(s)}$

---

**Question # 26**

From the information provided, what is the standard enthalpy of formation, $\Delta H^\circ_f$, for IF(g)?

$$\text{IF}_7(g) + \text{I}_2(g) \rightarrow \text{IF}_5(g) + 2 \text{IF}(g) \quad \Delta H^\circ_{\text{rxn}} = -89 \text{ kJ}$$

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A. 24 kJ/mol
B. 101 kJ/mol
✓C. −95 kJ/mol
D. −146 kJ/mol
E. −191 kJ/mol

Question #: 27

Given the following data, calculate the enthalpy of formation of H₂O(l).

\[ 2 \text{H}_3\text{BO}_3(s) + 6 \text{H}_2(g) \rightarrow \text{B}_2\text{H}_6(g) + 6 \text{H}_2\text{O}(l) \quad \Delta H^o = 510 \text{ kJ} \]

\( \Delta H^o_f \) of \( \text{H}_3\text{BO}_3(s) = -1094 \text{ kJ/mol} \)

\( \Delta H^o_f \) of \( \text{B}_2\text{H}_6(g) = 38 \text{ kJ/mol} \)

\( \Delta H^o_f \) of \( \text{H}_2\text{O}(l) = 1 \text{ kJ/mol} \)

Report your answer with three significant figures. Do NOT include units in your answer. Do NOT use scientific notation.

1. -286

Question #: 28

Bonus Question

A maximum of \_1_ grams of CO₂ can be produced from the reaction of 105 grams of CH₃OH with 61 grams of O₂.

\[ 2 \text{CH}_3\text{OH}(l) + 3 \text{O}_2(g) \rightarrow 2 \text{CO}_2(g) + 4 \text{H}_2\text{O}(l) \]

Report your answer with two significant figures. Do NOT include units in your answer. Do NOT use scientific notation.

1. 55|56|57|