HW13 - 1st Law and Calorimetry

1   1 point

A 100 W electric heater (1 W = 1 J/s) operates for 11 min to heat the gas in a cylinder. At the same time, the gas expands from 1 L to 6 L against a constant atmospheric pressure of 3.527 atm. What is the change in internal energy of the gas?

- ○ 48.37 kJ
- ○ 62.47 kJ
- ○ 67.79 kJ
- ○ 64.21 kJ

2   1 point

The definition of internal energy is
$\Delta U = q + w$
Which of these three values are state functions? Select all of the correct answers.

- ☐ q
- ☐ w
- ☐ ΔU

3   1 point

When 2.00 kJ of energy is transferred as heat to nitrogen in a cylinder fitted with a piston with an external pressure of 2.00 atm, the nitrogen gas expands from 2.00 to 5.00 L. What is the change in internal energy of this system?

- ○ -0.608 kJ
- ○ +2.61 kJ
- ○ -2.61 kJ
- ○ 0
- ○ +1.39 kJ

4   1 point

A system had 150 kJ of work done on it and its internal energy increased by 60 kJ. How much energy did the system gain or lose as heat?

- ○ The system lost 210 kJ of energy as heat.
- ○ The system gained 60 kJ of energy as heat.
- ○ The system gained 90 kJ of energy as heat.
- ○ The system lost 90 kJ of energy as heat.
- ○ The system gained 210 kJ of energy as heat.

5   1 point

If a process is carried out at constant pressure and the volume of the system decreases, then ΔV is

[_____] and the work is [_____] .

[⋮ positive] [⋮ negative] [⋮ positive] [⋮ negative] [⋮ zero]

6   1 point

Which of the following will best help determine the direction of heat flow in a system?

- ○ enthalpy
- ○ temperature
- ○ internal energy
- ○ pressure
- ○ work

7   1 point

Which of the following statements concerning the first law of thermodynamics is/are true? Select all of the correct answers.

- ☐ The internal energy of the universe is always increasing.
- ☐ The universe is an isolated system.
- ☐ Internal energy lost by a system is always gained by the surroundings.

8   1 point

What is the value of work when a piston of volume 0.2 L expands against an external pressure of 200 kPa to a volume of 3.4 L?

- ○ 3.40 kJ
- ○ -3.40 kJ
- ○ -640 J
- ○ 640 J

9   1 point

When 4.00 kJ of energy is transferred as heat to nitrogen in a cylinder fitted with a piston at an external pressure of 3.00 atm, the nitrogen gas expands from 1.00 L to 4.00 L against this constant pressure. What is ΔU for the process? Note: 1 L· atm = 0.1013 kJ.

- ○ -0.912 kJ
- ○ +3.09 kJ
- ○ -4.91 kJ
- ○ +4.91 kJ

~~**10**   1 point~~

~~A piece of metal with a mass of 22 g at 92 °C is placed in a calorimeter containing 53.7 g of water at 21 °C. The final temperature of the mixture is 55.3 °C. What is the specific heat capacity of the metal? Assume that there is no energy lost to the surroundings.~~

- ~~○ 9.5 J g⁻¹°C⁻¹~~
- ~~○ 1.3 x 10⁴ J g⁻¹ °C⁻¹~~
- ~~○ -1.3 x 10⁴ J g⁻¹ °C⁻¹~~
- ~~○ -9.5 J g⁻¹°C⁻¹~~

10   1 point

A piece of metal with a mass of 51.6 g at 92.2 °C is placed in a calorimeter containing 100 mL of water at 23.6 °C. The final temperature of the mixture is 27.2 °C. What is the specific heat capacity of the metal?

- ○ 0.951 J/g °C
- ○ 0.129 J/g °C
- ○ 0.412 J/g °C
- ○ 0.449 J/g °C
- ○ 0.385 J/g °C

11   1 point

Consider the following specific heat capacities:
H_2O (s) = 2.09 J/g·°C
H_2O (l) = 4.18 J/g·°C
H_2O (g) = 2.03 J/g·°C
The heat of fusion for water is 334 J/g and its heat of vaporization is 2260 J/g. Calculate the amount of heat required to convert 93 g of ice at -36°C completely to liquid water at 35°C.

- ○ 7 kJ
- ○ 52 kJ
- ○ 38 kJ
- ○ 21 kJ

12 1 point

The specific heat for liquid argon and gaseous argon is 25.0 J/mol·°C and 20.8 J/mol·°C, respectively. The enthalpy of vaporization of argon is 6506 J/mol. How much energy is required to convert 1 mole of liquid Ar from 5°C below its boiling point to 1 mole of gaseous Ar at 5°C above its boiling point?

○ 125 J

○ 229 J

○ 6610 J

○ 6735 J

○ 6631 J

13 1 point

Carbon monoxide reacts with oxygen to form carbon dioxide by the following reaction:
$2CO(g) + O_2(g) \rightarrow 2CO_2(g)$
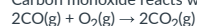
ΔH for this reaction is -135.28 kcal. How much heat would be released if 12.0 moles of carbon monoxide reacted with sufficient oxygen to produce carbon dioxide? Use only the information provided in this question.

○ 135 kcal

○ 812 kcal

○ 1620 kcal

○ 412 kcal

14 1 point

What mass of liquid ethanol (C_2H_5OH) must be burned to supply 500 kJ of heat? The standard enthalpy of combustion of ethanol at 298 K is -1368 kJ/mol.
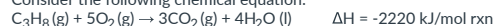
○ 10.9 g

○ 126 g

○ 16.8 g

○ 29.7 g

15 1 point

Burning 1 mol of methane in oxygen to form CO_2 (g) and H_2O (g) produces 803 kJ of energy. How much energy is produced when 3 mol of methane is burned?

○ 803 kJ

○ 268 kJ

○ 1606 kJ

○ 2409 kJ

16 1 point

Consider the following chemical equation:
C_3H_8 (g) + $5O_2$ (g) → $3CO_2$ (g) + $4H_2O$ (l) ΔH = -2220 kJ/mol rxn
How much thermal energy is given off when 11.0 g of propane gas (C_3H_8) is burned at constant pressure?

○ 26.0 kJ

○ 2220 kJ

○ 555 kJ

○ 1670 kJ

17 1 point

For a certain reaction at constant pressure, the change in internal energy is -52 kJ. In addition, the system does 46 kJ of expansion work. What is ΔH for this process?

○ 98 kJ

○ -98 kJ

○ -6 kJ

○ 6 kJ

18 1 point

If the products of a reaction have higher energy than the reactants, then the reaction...

○ is endothermic.

○ is not spontaneous.

○ is exothermic.

○ must be spontaneous.

19 1 point

The specific heats and densities of several materials are given below:

Material	Specific Heat (cal/g·°C)	Density (g/cm³)
Brick	0.220	2.0
Concrete	0.270	2.7
Steel	0.118	7
Water	1.00	1.00

Calculate the change in temperature produced by the addition of 1 kcal of heat to 100 g of steel.

○ 1.43°C

○ 37.0°C

○ 84.7°C

○ 1.18°C

20 1 point

A 1.00 g sample of n-hexane (C_6H_{14}) undergoes complete combustion with excess O_2 in a bomb calorimeter. The temperature of the 1502 g of water surrounding the bomb rises from 22.64°C to 29.30°C. The heat capacity of the hardware component of the calorimeter (everything that is not water) is 4042 J/°C. What is ΔU for the combustion of n-C_6H_{14}? One mole of n-C_6H_{14} is 86.1 g. The specific heat of water is 4.184 J/g·°C.

○ -9.96×10^3 kJ/mol

○ -5.92×10^3 kJ/mol

○ -4.52×10^3 kJ/mol

○ -1.15×10^4 kJ/mol

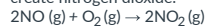**21** 1 point

When 0.485 g of compound X is burned completely in a bomb calorimeter containing 3000 g of water, a temperature rise of 0.285°C is observed. What is ΔU of the reaction for the combustion of compound X? The hardware component of the calorimeter has a heat capacity of 3.81 kJ/°C. The specific heat of water is 4.184 J/g·°C, and the MW of X is 56.0 g/mol.

○ -4660 kJ/mol

○ 4660 kJ/mol

○ 538 kJ/mol

○ -538 kJ/mol

22 1 point

Nitric acid can be manufactured in a multi-step process, during which nitric oxide is oxidized to create nitrogen dioxide.
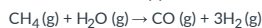
$2NO (g) + O_2 (g) \rightarrow 2NO_2 (g)$

Calculate the standard reaction enthalpy for the above reaction using the following thermodynamic data.

$N_2 (g) + O_2 (g) \rightarrow 2NO (g)$ $\Delta H°_1 = 180.5$ kJ/mol rxn

$N_2 (g) + 2O_2 (g) \rightarrow 2NO_2 (g)$ $\Delta H°_2 = 66.4$ kJ/mol rxn
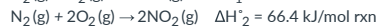
- ○ -246.9 kJ/mol rxn
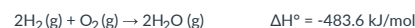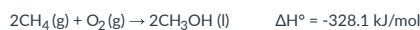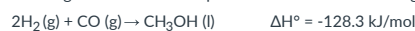- ○ -252.4 kJ/mol rxn
- ○ -100.3 kJ/mol rxn
- ○ -114.1 kJ/mol rxn

23 1 point

Calculate the standard reaction enthalpy for the following chemical equation.
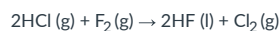
$CH_4 (g) + H_2O (g) \rightarrow CO (g) + 3H_2 (g)$

Use the following thermochemical equations to solve for the change in enthalpy.

$2H_2 (g) + CO (g) \rightarrow CH_3OH (l)$ $\Delta H° = -128.3$ kJ/mol

$2CH_4 (g) + O_2 (g) \rightarrow 2CH_3OH (l)$ $\Delta H° = -328.1$ kJ/mol

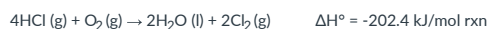$2H_2 (g) + O_2 (g) \rightarrow 2H_2O (g)$ $\Delta H° = -483.6$ kJ/mol

- ○ +216 kJ/mol   ○ +155.5 kJ/mol
- ○ +206.1 kJ/mol   ○ +42.0 kJ/mol

24 1 point

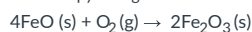Calculate the standard enthalpy change for the following chemical equation.

$2HCl (g) + F_2 (g) \rightarrow 2HF (l) + Cl_2 (g)$

Use the following thermochemical equations to solve for the change in enthalpy.

$4HCl (g) + O_2 (g) \rightarrow 2H_2O (l) + 2Cl_2 (g)$ $\Delta H° = -202.4$ kJ/mol rxn

$\frac{1}{2}H_2 (g) + \frac{1}{2}F_2 (g) \rightarrow HF (l)$ $\Delta H° = -600.0$ kJ/mol rxn

$H_2 (g) + \frac{1}{2}O_2 (g) \rightarrow H_2O (l)$ $\Delta H° = -285.8$ kJ/mol rxn
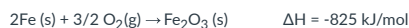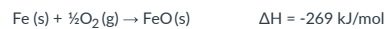
- ○ +1088.2 kJ/mol rxn   ○ +516.6 kJ/mol rxn
- ○ -1116.6 kJ/mol rxn   ○ +1015.4 kJ/mol rxn
- ○ +1116.6 kJ/mol rxn   ○ -516.6 kJ/mol rxn
- ○ -1587.2 kJ/mol rxn   ○ -1015.4 kJ/mol rxn
- ○ -1088.2 kJ/mol rxn   ○ +1587.2 kJ/mol rxn

25 1 point

Calculate the standard enthalpy change for the following chemical equation.

$4FeO (s) + O_2 (g) \rightarrow 2Fe_2O_3 (s)$

Use the following thermochemical equations to solve for the change in enthalpy.

$Fe (s) + \frac{1}{2}O_2 (g) \rightarrow FeO (s)$ $\Delta H = -269$ kJ/mol

$2Fe (s) + 3/2 O_2(g) \rightarrow Fe_2O_3 (s)$ $\Delta H = -825$ kJ/mol
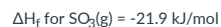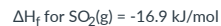
- ○ 556 kJ/mol   ○ -2726 kJ/mol
- ○ 574 kJ/mol   ○ -556 kJ/mol
- ○ -574 kJ/mol

26 1 point

Calculate the enthalpy change for the following chemical equation.

$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$
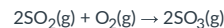
Use the following thermochemical data to solve for the change in enthalpy.

ΔH_f for $SO_2(g) = -16.9$ kJ/mol

ΔH_f for $SO_3(g) = -21.9$ kJ/mol

- ○ -77.6 kJ/mol rxn   ○ -5.0 kJ/mol rxn
- ○ -10.0 kJ/mol rxn   ○ +5.0 kJ/mol rxn

27 1 point

Which of the following substances have $\Delta H_f° = 0$? Select all of the correct answers.

- ☐ $F_2 (g)$
- ☐ C (s, graphite)
- ☐ HCl (g)
- ☐ Na (s)
- ☐ HCl (aq)
- ☐ C (s, diamond)

28 1 point

Calculate the average S–F bond energy in SF_6 using the following ΔH_f values:

$SF_6 (g) = -1209$ kJ/mol

S (g) = 279 kJ/mol

F (g) = 79 kJ/mol

- ○ 289 kJ/mol bonds   ○ 582 kJ/mol bonds
- ○ 196 kJ/mol bonds   ○ 327 kJ/mol bonds
- ○ 416 kJ/mol bonds

29 1 point

Using the bond energy data provided, calculate ΔH for the following reaction:

$H_2 (g) + Cl_2 (g) \rightarrow 2HCl (g)$

Bond Energies

H–H	436 kJ/mol
Cl–Cl	242 kJ/mol
H–Cl	432 kJ/mol

- ○ 186 kJ/mol   ○ -246 kJ/mol
- ○ 246 kJ/mol   ○ -186 kJ/mol

30 1 point

The standard molar enthalpy of formation of $NH_3 (g)$ is -46.11 kJ/mol. What is the standard molar internal energy of formation of $NH_3 (g)$?

- ○ -48.59 kJ/mol
- ○ 2433 kJ/mol
- ○ -43.63 kJ/mol
- ○ -2525 kJ/mol