Eng Gen 140

Energy transfer / thermodynamics

- collected questions -

from
(course book)

6.9 Practice problems [solutions posted on Canvas]

1. Calculate ΔH if a piece of metal with a specific heat of 0.98 $kJ \cdot kg^{-1} \cdot K^{-1}$ and a mass of 2 kg is heated from 22°C to 28°C.
2. If a calorimeter's ΔH is +2001 Joules, how much heat did the substance inside the cup lose?
3. Calculate the ΔH of the following reaction: CO_2 (g) + H2O (g) → H_2CO_3 (g) if the standard values of ΔH_f are as follows: CO_2 (g): -393.509 $kJ.mol^{-1}$, H_2O (g) : -241.83 $kJ.mol^{-1}$, and H_2CO_3(g) : -275.2 $kJ.mol^{-1}$.
4. Calculate ΔH if a piece of aluminum with a specific heat of .9 $kJ \cdot kg^{-1} \cdot K^{-1}$ and a mass of 1.6 kg is heated from 286°K to 299°K.
5. If the calculated value of ΔH is positive, does that correspond to an endothermic reaction or an exothermic reaction?
6. How much heat is absorbed by air having an initial volume of 18m^3 at 1.013 x 10^5 Pa when the air temperature rises from 17°C to 25°C. The average molecular mass of air is 28.8 $g.mol^{-1}$. Assume constant pressure. c_p for air molecules = 1.01 $J.g^{-1}.K^{-1}$
7. Assuming you had a propane heater, determine how much propane would be needed to achieve the temperature change from Q6 above (energy density of propane is -50.4 MJ/kg).

(2017 Worksheet).

Thermodynamics – Worksheet 1

1. The following processes are performed by a gas at initial pressure of 200kPa and volume of $1m^3$:
   Process I: Isovolumetric (isochoric) increase in pressure to 1400 kPa.
   Process II: Isobaric compression to $0.5m^3$
   Process III: Isovolumetric (isochoric) decrease in pressure to 200 kPa
   Process IV: Isobaric expansion to $1.0m^3$.
   a. Draw a pressure-volume diagram of these processes. Indicate each process, label the axes and make sure you show arrows to indicate the direction of each path.
   b. Calculate the net work done by the gas in this system.
   c. What is the net change in internal energy for this system?

2. A reversible heat engine operates between a hot reservoir at 900K and a cold reservoir at 500K.
   a. Calculate the efficiency of the engine.
   b. The temperature of one of the heat reservoirs can be changed by 100 degrees kelvin up or down. What is the highest efficiency that can be achieved by making this temperature change?

3. In one sentence, briefly state the First Law of Thermodynamics

4. Draw the idealised Otto Cycle on a PV diagram. On this diagram label the area that corresponds to adiabatic expansion work done by the gas.

5. An ideal gas, n=0.450, initially at T_1 = 350K, $P_1 = 1.013 \times 10^5$ Pa and $V_1 = 1.29 \times 10^{-2}$ m^3, undergoes the following sequential processes in a closed system:
   Process I: Isovolumetric cooling to T_2 = 298 K, $P_2 = 8.63 \times 10^4$ Pa
   Process II: Isobaric expansion to V_3 = 13.5L and T_3 = 311K
   Process III: Adiabatic compression to P_4 = 101.3 kPa and $V_4 = 1.29 \times 10^{-2}$ m^3
   a. Sketch the process on a PV diagram, label the axes, label each process and use arrows to show the direction of each process
   b. Calculate the net work done by the gas. Show your calculations. Indicate if the net work is positive or negative.

6. a. An engine using a piston-cylinder operates on an ideal Otto cycle. In the compression stage -357 J of work are done on the gas; 383.5 J of heat are transferred to the gas at the beginning of the power stroke and the gas does 580.8 J of work in expansion. The temperature at the beginning of the compression step is 325K and at the end of the power stroke is 529K. What is the efficiency of the engine?
   b. Give ONE reason why the actual engine efficiency will be lower than the value calculated above.

7. Use the ideal gas law (PV = nRT) and the equations for gas expansion/compression work to calculate the work done by a gas when one mole of carbon monoxide gas, contained in a piston undergoes the following sequential changes:
   a. Isothermal expansion at 700 K from 2.758×10^6 Pa and 2.110×10^{-3} m^3 to 5.520×10^5 Pa and 1.054×10^{-2} m^3.
   b. Cooled at constant volume from 700 K and 5.52×10^5 Pa to 437.5 K and 3.45×10^5 Pa.
   c. Cooled at constant pressure, 3.451×10^5 Pa from 437.5 K to 350 K.
   d. Compressed adiabatically from 3.451×10^5 Pa at 350K to 2.758×10^6 Pa at 634 K.
   e. Heated at constant pressure, 2.758×10^6 Pa from 634 K to 700 K.

(2017 Exam)

QUESTION/ANSWER BOOKLET **ENGGEN 140**

ID: ………………………….

Thermodynamics – 24 marks

29) Which are the following statements is FALSE, regarding properties of a thermodynamic system: **(1 mark)**

A. Extensive properties can be converted to intensive properties by dividing by moles
B. Intensive properties are independent of the quantity of matter
C. Volume is an extensive property
D. Heat is a property of the system
E. Temperature is a property of the system

Answer: ____________

30) One mole of an ideal gas, initially at $T_1 = 25°C$, $P_1 = 101.3$ kPa and $V_1 = 24.5 \times 10^{-3}$ m^3, undergoes the following mechanically reversible processes in a closed system:

Process I: Adiabatic compression to $T_2 = 473$ K, $P_2 = 505$ kPa, and $V_2 = 7.65 \times 10^{-3}$ m^3.
Process II: Isobaric cooling to $T_3 = 25°C$, and $V_3 = 4.89 \times 10^{-3}$ m^3.

a. Draw these two processes on a pressure-volume graph, label the axes, identify each state, process and path. **(3 marks)**

2017 Exam cont'd.

ID: …………………………

b. Calculate the enthalpy change (ΔH) and work (W) for each step of the process. Take $Cp = (7/2)R$, where R is the Universal Gas Constant. Assume an adiabatic constant, γ of 1.4. Show your working. **(4 marks)**

Process I ΔH: ____________

Process I W: _____________

Process II ΔH: ____________

Process II W: _____________

31) Briefly define Internal Energy, U **(1 mark)**

32) During an adiabatic process, the system is isolated, so there is no heat lost to the surrounds. In this case, what is the relationship between Internal Energy (ΔU), Heat (Q), and Work (W) **(1 mark)**

Answer:

2017 Exam cont'd.

ID: ....

33) A 450g sample of Nickel is heated from 25 ºC to 100 ºC. The amount of energy required is 14.85 kJ. What is the specific heat capacity of Nickel? **(2 marks)**

Answer:

34) Solid sulphur is commonly formed at the vents of volcanoes in a reaction between hydrogen sulphide and sulphur dioxide gases

$$16H_2S(g) + 8SO_2\ (g) \rightarrow 16H_2O + 3S_8\ (s)$$

The enthalpy change ΔH = -1876 kJ / mol
The entropy change ΔS = -3.424 kJ / mol °K

a. Is this reaction exothermic or endothermic? **(1 mark)**

Answer: ____________________________

b. Why is the entropy change for this reaction negative? **(1 mark)**

Answer:

c. Is this reaction exergonic or endergonic at temperature T = 298K? Justify your answer. **(2 marks)**

Answer:

d. Does this reaction take place spontaneously at 298K? Justify your answer. **(1 mark)**

Answer: