CADET ____________________ SECTION ______TIME OF DEPARTURE ________

DEPARTMENT OF CHEMISTRY & LIFE SCIENCE

CH365 2022-2023
WRITTEN PARTIAL REVIEW II
12 October 2022, A-Hour

TEXT: Smith, Van Ness, Abbott & Swihart
SCOPE: Lessons 10-20
TIME: 55 Minutes

References Permitted: Open notes, book, internet, CHEMCAD, Mathematica, Excel.

INSTRUCTIONS

1. Do not mark this exam or open it until “begin work” is given.
2. You have 55 minutes to complete the exam.
3. Solve the problems in the space provided. Show all work to receive full credit.
4. There are 3 problems on 4 pages in this exam (not including the cover page). Write your name on the top of each sheet.
5. Save CHEMCAD and Mathematica files on your desktop and re-save frequently.
6. Upload all CHEMCAD and Mathematica files to your SharePoint directory.
7. **The file name of uploaded files must be written clearly on the exam.**

(TOTAL WEIGHT: 200 POINTS)

DO NOT WRITE IN THIS SPACE

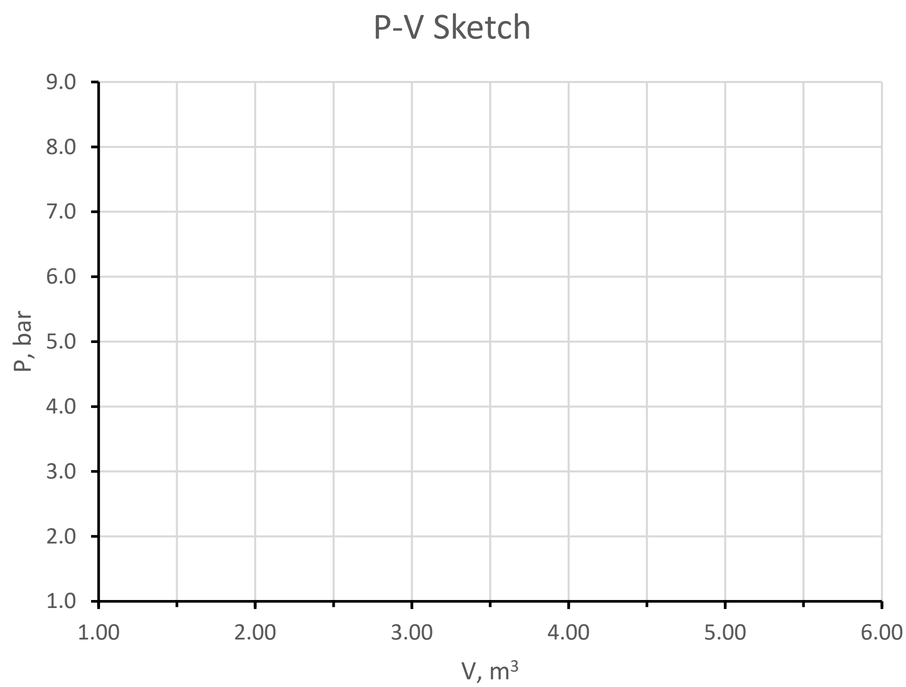
PROBLEM	VALUE	CUT
A	80	
B	70	
C	50	
TOTAL CUT		
TOTAL GRADE	200	

Cadet:________________________

<u>Problem:</u> <u>Weight:</u>
A 80

0.200 kmol of an ideal gas in a closed system is changed from an initial state of 5.0 m^3, 2.0 bar and 721.7 K to a final state of 2.0 m^3, 5.0 bar, and 721.7 K by a two-step process consisting of an adiabatic compression followed by cooling at constant volume. (a) Sketch the process path in the PV axes below. (b) Calculate Q, W, ΔU and ΔH for the overall process <u>in units of kJ</u>. (c) Calculate the intermediate temperature after step 1.

$$R = 8.314\ J/(mol \cdot K) = 0.08314\ (bar \cdot m^3)/(kmol \cdot K)$$
$$C_P = (7/2) \cdot R, \text{ and}$$
$$C_V = (5/2) \cdot R$$



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Cadet:________________________

<u>Problem:</u> <u>Weight:</u>
B 70

An engineering plan for a vinyl chloride plant includes a pipeline carrying chlorine (Cl_2) at a volumetric flow rate of 3.402 MMSCFD (million standard cubic feet per day). Standard conditions are 60°F and 1.00 atm.

Use the Peng-Robinson (PR) equation of state, Table 3.1, and gas constant R = 10.73 $ft^3 \cdot psia/(lbmol \cdot R)$ to determine the molar flow rate of Cl_2 in lbmol/d.

Cadet:______________________

Problem: Weight:
C 50

Hydrogenation refers to the treatment of substances with hydrogen, H_2. Hydrogenation is important in the petrochemical and food processing industries. For example, hydrogenation of polyunsaturated fatty acids in vegetable oils reduces most of the carbon-carbon double bonds, making the oil safer and healthier for consumption. Hydrogenation reactions of hydrocarbons typically involve the reaction of alkenes with hydrogen to form alkanes at high temperatures and pressures, usually over a supported metal catalyst such as Raney nickel. Steam is often used as a diluent to control the temperature in the reactor. In this problem, you will consider the hydrogenation of propylene to form propane:

$$C_3H_6(g) + H_2(g) \rightarrow C_3H_8(g)$$

Calculate the standard gas-phase heat of hydrogenation of propylene at 43$\underline{5}$ °C and 1.00 bar in 50% excess hydrogen, with 4.00 moles of steam added per mole of propylene as a diluent to control the reactor temperature. The process is isothermal with reactants and products at 43$\underline{5}$ °C.

The following table contains ideal gas heat capacity polynomial coefficients and standard heats of formation at 298 K from Appendix C:

species	a	$b\times10^3$	$c\times10^6$	$d\times10^{-5}$	$\Delta H^0_{f,298}$, J/mol
C_3H_6	1.637	22.706	-6.915	0.000	19,710
H_2	3.249	0.422	0.000	0.083	0
H_2O	3.470	1.450	0.000	0.121	-241,818
C_3H_8	1.213	28.785	-8.824	0.000	-104,680

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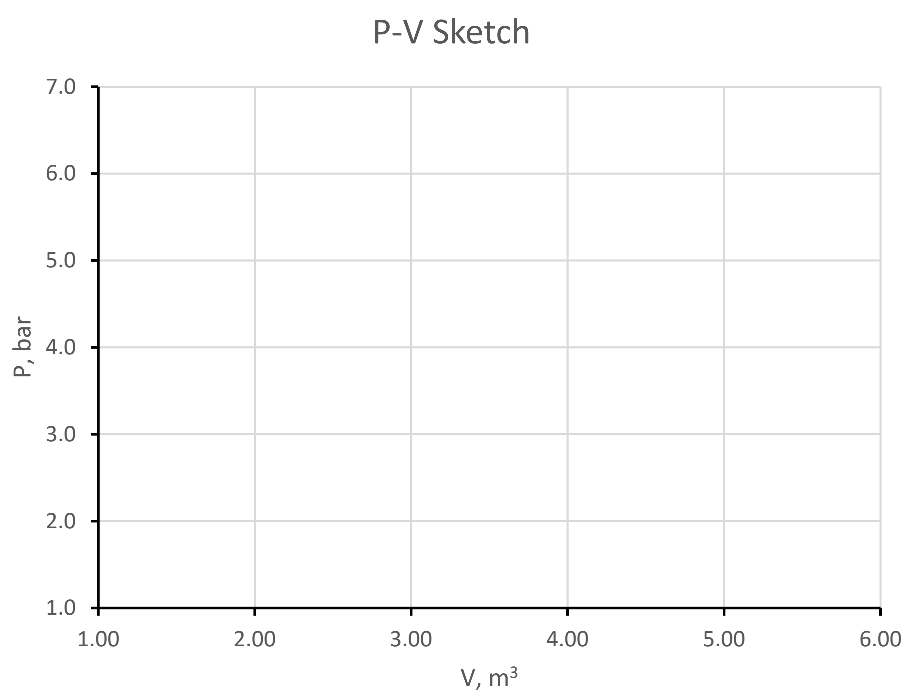
PROBLEM	VALUE	CUT
A	80	
B	70	
C	50	
TOTAL CUT		
TOTAL GRADE	200	

Cadet:________________________

<u>Problem:</u> <u>Weight:</u>
A 80

0.400 kmol of an ideal gas in a closed system is changed from an initial state of 5.0 m^3, 2.0 bar and 300.7 K to a final state of 2.0 m^3, 5.0 bar, and 300.7 K by a two-step process consisting of an adiabatic compression followed by cooling at constant pressure. (a) Sketch the process path in the PV axes below. (b) Calculate Q, W, ΔU and ΔH for the overall process <u>in units of kJ</u>. (c) Calculate the intermediate temperature after step 1.

$$R = 8.314\ J/(mol\cdot K) = 0.08314\ (bar\cdot m^3)/(kmol\cdot K)$$
$$C_P = (7/2)\cdot R, \text{ and}$$
$$C_V = (5/2)\cdot R$$



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Problem: Weight:
B 70

An engineering plan for a vinyl chloride plant includes a pipeline carrying ethylene (C_2H_4) at a volumetric flow rate of 7.530 MMSCFD (million standard cubic feet per day). Standard conditions are 60°F and 1.00 atm.

Use the Peng-Robinson (PR) equation of state, Table 3.1, and gas constant R = 10.73 $ft^3 \cdot psia/(lbmol \cdot R)$ to determine the molar flow rate of C_2H_4 in lbmol/d.

Cadet:________________________

<u>Problem:</u> <u>Weight:</u>
C 50

Hydrogenation refers to the treatment of substances with hydrogen, H_2. Hydrogenation is important in the petrochemical and food processing industries. For example, hydrogenation of polyunsaturated fatty acids in vegetable oils reduces most of the carbon-carbon double bonds, making the oil safer and healthier for consumption. Hydrogenation reactions of hydrocarbons typically involve the reaction of alkenes with hydrogen to form alkanes at high temperatures and pressures, usually over a supported metal catalyst such as Raney nickel. Steam is often used as a diluent to control the temperature in the reactor. In this problem, you will consider the hydrogenation of 1-butene to form n-butane:

$$C_4H_8(g) + H_2(g) \rightarrow C_4H_{10}(g)$$

Calculate the standard gas-phase heat of hydrogenation of 1-butene at 57<u>5</u> °C and 12.00 bar in 80% excess hydrogen, with 18.00 moles of steam added per mole of propylene as a diluent to control the reactor temperature. The process is isothermal with reactants and products at 57<u>5</u> °C.

The following table contains ideal gas heat capacity polynomial coefficients and standard heats of formation at 298 K from Appendix C:

species	a	$b\times10^3$	$c\times10^6$	$d\times10^{-5}$	$\Delta H^0_{f,298}$, J/mol
C_4H_8	1.967	31.630	-9.873	0.000	-540
H_2	3.249	0.422	0.000	0.083	0
H_2O	3.470	1.450	0.000	0.121	-241,818
C_4H_{10}	1.935	36.915	-11.402	0.000	-125,790