Department of Electrical Engineering
Assignment
Date: 22/06/2020

Course Details

Course Title: Thermodynamics **Module:** 02
Instructor: _____ **Total Marks:** 50

Student Details

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Q1.	(a) i. ii.	**State** the following along with their mathematical expressions: The ideal gas law Dalton's law of partial pressure	Marks 04+06 CLO 2
	(b)	**Explain** the Carnot cycle.	
Q2.	(a)	You need to buy a refrigerator for your home. **Outline** the key factors that you will consider while buying the refrigerator.	Marks 05+08 CLO 3
	(b)	**Explain** vapour absorption refrigeration system.	
Q3.		**Distinguish** between water tube & fire tube boilers.	Marks 06 CLO 3
Q4.		State the meaning of the word "stroke" & **describe** the working of a 04 stroke engine.	Marks 12 CLO 3
Q5.	(a)	**Outline** the differences between a petrol engine & a diesel engine.	Marks 04+05
	(b)	Several provincial governments in Pakistan have banned the use of 02 stroke engines in auto rickshaws. **Identify** the causes behind this decision.	CLO 3

QUESTION: 01

PART (a)

(i) IDEAL GAS LAW:

This law states that

" the law that the product of the pressure and the volume of one gram molecule of an ideal gas is equal to the product of the absolute temperature of the gas and universal gas constant."

OR

"Ideal gas is the gas that conforms, in physical behaviour, to a particular, idealized relation between pressure, volume and temperature, called the ideal gas law"

It was first stated by Emile Clapeyron in 1834 as a combination of Emperical Boyle's law, Charle's law, Avogadro's law and Gay-Lussac's law.

EQUATION:

The state of an amount of a gas is determined by its pressure, volume and temperature. The modern

form of the equation relates these simply in two main forms. The temperature used in equation, is absolute temperature; the appropriate SI Unit used is Kelvin.

COMMON FORM

The frequent introduced form is

$$pV = nRT$$

p = pressure of gas in pascals
V = volume of gas in cubic meters
n = amount of substance of gas in moles
R = ideal gas constant
= 8.314 J/K.mol or 2 cal/K.mol
or 0.0821 L.atm/mol.K

Molar form

How much gas is present could be specified by giving the mass instead of chemical amount of gas. Therefore an alternative form of ideal gas law may be useful. The chemical amount in moles is equal to total mass of gas (m) divided by Molar mass (M)

$$n = \frac{m}{M}$$

By replacing n in gas law we get

$$pV = \frac{mRT}{M}$$

$$p = \frac{mRT}{MV} \qquad \therefore \frac{m}{V} = \text{density}$$

$$p = \rho \frac{RT}{M}$$

$$p = \rho R_{specific} T \qquad \therefore \frac{R}{M} = R_{specific}$$

Alternatively law can be written in terms of specific volume V reciprocal of density as

$$\boxed{pv = R_{spe} \cdot T}$$

(ii) DALTON'S LAW (OF PARTIAL PRESSURE)

Dalton's law or law of partial pressure states that

"the total pressure exerted by a mixture of gases is equal to the sum of partial pressures of gases in mixture."

DERIVATION:

A gas filled in container will expand without affecting pressure of another gas present. So, it can be concluded that

pressure of certain gas is based on number of moles of that gas and volume and temp of system.

Each gas exert its own pressure on the system which can be added up to find total pressure shown by equation

$$P_{total} = P_A + P_B + \cdots$$

We have from ideal gas equation

$$PV = nRT$$

$$n_{total} = n_a + n_b + n_c + \cdots$$

So

$$\boxed{P_{total} V = n_{total} RT}$$

We can rearrange this equation to find total numbers of moles as well keeping volume and temp constant.

PART (b)

CARNOT CYCLE:

It was appointed by Sadi Carnot that even an ideal engine under ideal conditions can not completely convert absorbed heat into work. Only a fraction is converted and that fraction is determined by operating temperature and does not depend upon nature of engine.

COMPOSITION:

The extent to which work can be obtained from heat and its dependence on the temperatures of source and sink is given by Carnot cycle. The carnot heat engine consists of a cylinder fitted with an ideal piston and contains a mole of an ideal gas as working substance. The engine operates reversibly in cycles between two large heat reservoirs. (high temp source, low temp sink). In a complete cycle, the engine absorbs a quantity of heat (q_1) from source, converts a part into work (W) and rest q_2 is transformed to sink at lower temperature.

Working:

The cycle involves four reversible steps two are performed isothermally and other two under adiabatic condition.

Step: 1

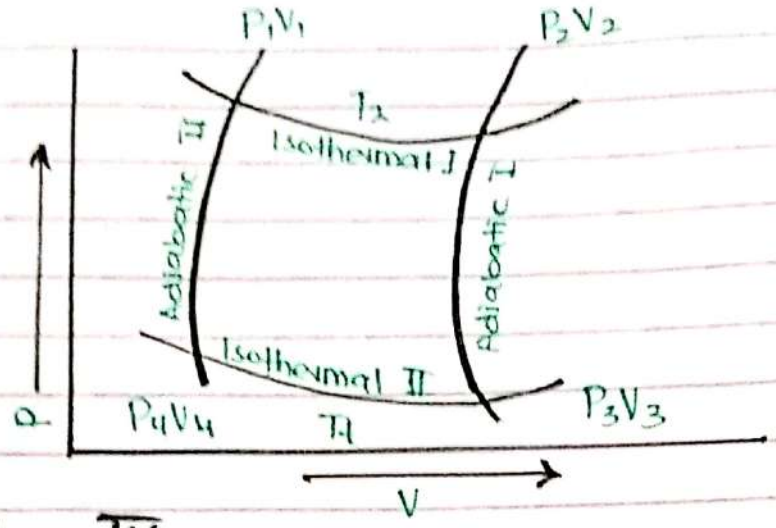
Gas cylinder is placed in contact with reservoir at T_2 and gas is allowed to expand from initial volume V_1 to V_2. Pressure also changes from P_1 to P_2. Since process is isothermal and reversible one, $\Delta E = 0$. If q_2 is heat absorbed and W_1 is work done than according to 1st law of thermodynamics.

$$q_2 = W_1 = RT_2 \ln \frac{V_2}{V_1}$$

Step II:

Cylinder is removed from source, sorrounded by thermally insulated enclosure and gas is allowed to flow from V_2 to V_3 untill temp drops to T_1. Since expansion is adiabatic hence $q = 0$ and adiabatic work is given by

$$W_2 = -\Delta E = -C_v(T_1 - T_2) = C_v(T_2 - T_1)$$



Step III

thermal isolation is removed. Gas is compressed isothermally from V_3 to V_4. If q_1 is heat given out by the gas than reversible work is given by

$$-q_1 = W_3 = RT_1 \ln \frac{V_4}{V_3}$$

Step IV

Gas is compressed from V_4 to V_1. Work of compression is given by

$$W_4 = -C_v(T_2 - T_1).$$

The system returns to its original state and cycle is completed. Net work done is calculated by.

$$W = W_1 + W_2 + W_3 + W_4$$

$$= RT_2 \ln \frac{V_2}{V_1} + C_v(T_2 - T_1) + RT_1 \ln \frac{V_4}{V_3} + C_v(T_2 - T_1)$$

$$= RT_2 \ln \frac{V_2}{V_1} + RT_1 \ln \frac{V_4}{V_3}$$

On dividing we get

$$\frac{V_2}{V_1} = \frac{V_3}{V_4} \qquad \therefore TV^{\gamma-1}$$

Net work is

$$W = RT_2 \ln \frac{V_2}{V_1} - RT_1 \ln \frac{V_3}{V_4}$$

$$= RT \ln \frac{V_2}{V_1} - RT_1 \ln \frac{V_2}{V_1}$$

$$= R(T_2 - T_1) \ln \frac{V_2}{V_1}$$

shows that out of heat $q \left(= RT_2 \ln \frac{V_2}{V_1}\right)$ absorbed by the system from heat reservoir in first step

$$W = R(T_2 - T_1) \ln \frac{V_2}{V_1}$$

is converted into work. The difference is usually loss to sink.

QUESTION: 02 PART (a)

KEY FACTORS FOR BUYING REFRIGERATOR

Buying a refrigerator is a significant investment. With all the options available, shoping for new one can be over whelming.

Here are 5 important factors which can be kept under consideration while buying refrigerator.

Styles:

Models fridges come in a variety of layout. Most common styles are top freezer or bottom freezers or side by side. Traditional styles have freezers on top. Bottom freezer options are convinient because refrigerated compartment is easily accessible at eye level.

Features:

Adjustable shelves customized you to adjust your space. Indoor water and ice dispensers are popular with many people. Some models have special temp-controlled drawers to

keep certain food freshers.

In-charge large:

Fridge drawers are the ideal complement. These are typically built into the cabinetry and take up about as much as a dishwasher.

Energy Efficiency:

New one uses less energy which translates into savings for you and less environmental impact. Look for refrigerators that are Energy STAR notified.

Finish:

Options for finishes seem to grow every year. Stainless steel is still popular, especially since the advent of new smudge resistant versions. For a high-end look, some built in models built in models can be customized to blend with your cabinets.

PART (b)

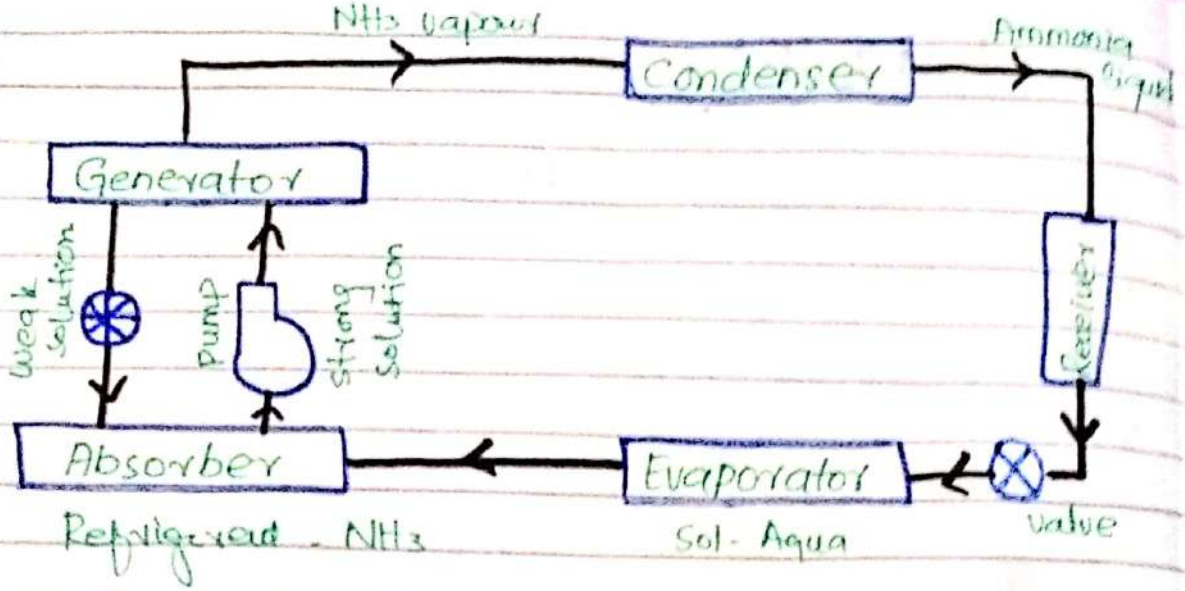
VAPOUR ABSORPTION REFRIGERATION SYSTEM:

Vapour absorption refrigeration system comprises of all processes in the vapour compression refrigeration system like compression, condensation, expansion and evaporation. In the vapour absorption system the refrigerant used is ammonia, water and lithium bromide. The refrigerant get condensed in the condensor and gets evaporated in evaporator. The refrigerant produces cooling effect in evaporator and releases heat to atmosphere via condensor.

Working

It works in 4 steps

- Condenser
- Expansion Valve
- Evaporator
- Absorber



QUESTION: 03

DIFFERENCE:

	FIRE TUBE BOILER	WATER TUBE BOILER
1	Hot tube gases pass through them and water sorrounds them.	Water passes and hot flue gases sorrounds them.
2	Operated at low pressures upto 20 bar	Working pressure is high enough upto 250 bars.
3	Load fluctuations can't be handled	Load fluctuations can be easily handled.

4	Requires more floor area for output.	Requires less floor area for given output.
5	Bulky and difficult to transport	Light in weight.
6	Overall efficiency is about 75%.	Efficiency is upto 90%.
7	Water doesn't circulate in definite direction	Direction of water circulated is well defined
8	Drum size is large and damage caused by bursting is large	If any water tube is damaged it can be easily replaced.

QUESTION: 04

Stroke:

According to dictionary the word "stroke is an act of hitting or striking someone or something, a blow"

OR

"a mark made by drawing a pen, pencil or paintbrush in

one direction across paper or canvass.

OR

"move ones hand gentle pressure over a surface, typically repeatedly

Working of 4 Stroke Engine System:

A four stroke engine works in four steps to complete the cycle. Each engine has 4 openings for intake, exhaust, fuel injection, spark plug. The piston is driven. The various process are listed below:

INTAKE STROKE:

Where intake values are open and air is drawn into cylinder. Fuel injector sprays fuel in cylinder. Downward movement of piston causes the air and fuel to be sucked into the cylinder.

COMPRESSION STROKE:

Here both intake and exhaust values are closed. Upward movement of piston causes air-fuel mixture to be compressed upwards

towards spark plug. This compression makes an compression volatile for easier ignition.

POWER STROKE:

Both valves are still closed. Spark plug produces spark to ignite the compressed fuel mixture. Energy of combustion forcefully pushes the piston downward.

EXHAUST STROKE:

last cycle is the exhaust stroke, when the exhaust valves open and exhaust gases are forced up by returning piston.

QUESTION: 05

part (a)

Diesel Engine	Petrol Engine
• Works on diesel cycle	Works on otto cycle
• Fuel is mixed in air inside cyclinder	Air and fuel are mixed in carburettor

• High compression ratio	Relatively low compression ratio
• Relatively low fuel consumption	High fuel consumption.
• High initial and maintainence cost	Comparatively low initial and maintaince cost.
• High power production	Relatively low power production.
• Work with fuels having low volatalies	High volatile fuels are used.
• Ignition is achieved with hot compressed air	Fuel is ignited with electric spark.

Part (b)

Causes:

Banning of two stroke engine in auto rikshaws is discussed in different contents here. Such as its impact on

→ socio-economic status of rikshaw drivers

→ factory workers engaged in rikshaw manufacture

→ Rikshaw users etc.
