BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI, DUBAI CAMPUS

I SEMESTER 2012-2013

COMPREHENSIVE EXAMINATION

Year : II-MECHANICAL	**Section: 1 and 2**	**Date : 31.12.2012**
Course No. : ME F214	**Course Title : APPLIED THERMODYNAMICS**	
Duration : 3hrs	**Marks: 80**	**Weightage : 40 %**

Note: (i) *Answer all the questions*

(ii) *Draw neat sketches wherever necessary*

(iii) *Make suitable assumptions if required and clearly state them*

(iv) Steam table will be provided

(v) psychrometric is attached in the 4 page

Q.1 An engine working on otto cycle has a volume of **$0.5m^3$**, pressure **1** bar and temperature **27^0C** at the commencement of compression stroke. At the end of the compression stroke the pressure is **10 bar**. Heat added during the constant volume process is **200 kJ.** Calculate the pressure, temperature and volumes at salient points in the cycle.

Also find (a) percentage clearance (b) heat rejected by cycle (c) air standard efficiency and (d) mean effective pressure in bar.

If the engine runs at **400** rev/min, so that there are **200** complete cycles per minute, calculate work done per minute developed by the engine. Take **R** for air = **0.287** kJ/kgk; **c_v = 0.718** kJ / kg-K and **γ = 1.4** [11 M]

Q.2 In a thermal power plant operating on an ideal Rankine cycle, superheated steam produced at **5 Mpa** and **500^0C** is fed to a turbine where it expands to the condenser pressure of **10kPa**, Determine: (a) Pump work per kg of steam (b) Heat added to the boiler per kg of steam (c) Turbine work per kg of steam (d) Rankine efficiency (e) Specific steam consumption

If the net power output of the plant is to be **20** MW, Find out (f) Mass flow rate of steam in kg/s (g) mass flow rate of cooling water in the condenser. Assume the cooling water enters the condenser at **25^0C** and leaves at **35^0C**. Take specific .heat of water **C_P = 4.186** kJ/kg-K [11 M]

Q.3 A vapour compression refrigeration plant operates between evaporation and condensation temperatures of **-10^{0}C** and **45^{0}C** respectively. The condensation temperature is further sub cooled, so that the liquid refrigerant enters the expansion valve at **35^{0}C**. The refrigerant is dry and saturated vapour at the entry to the compressor. It is discharged at **102^{0}C** from the compressor. The bore and stroke of the compressor are **80 mm** each. It runs at **720** rpm with volumetric efficiency of **80 %**.

Take specific heat of liquid refrigerant = **1.62 kJ/kg-k.** Use the relation for enthalpy of sub-cooled by the refrigerant is [$h_f - c_p (T_{cond} - T_{sup\ cooled})$].

Use the properties of refrigerant tabulated below:

Sat. temperature	V_g	h_f kJ/kg	h_g kJ/kg	S_f kJ/kg-K	S_g kJ/kg-K
-10°C	0.233	45.4	460.7	0.183	1.762
45°C	0.046	133.0	488.6	0.485	1.587

Determine (a)Specific heat of refrigerant vapor (b) Work done by the compressor in kJ/kg (c) Refrigerating effect in kJ/kg (d) COP of cycle (e) Theoretical swept volume in m^3/min (f) Mass flow rate of refrigerant in kg/min (g) Capacity of the plant in TR [12 M]

Q.4 The sling psychrometer in a laboratory test recorded the dry bulb temperature is **35^{0}C**, wet bulb temperature **25 ^{0}C**. Calculate (a) Specific humidity (b) relative humidity (c) dew point temperature (d) enthalpy of mixture per kg of dry air. Take atmosphere pressure =**1.0132** bar and partial pressure of vapour = **0.0252** bar [5 M]

Q.5 A gas turbine until receives air at **1 bar** and **300K** and compresses it adiabatically to **6.2** bar. The compressor efficiency is **88 %**. The fuel has a heating value of **44186** kJ/kg and the fuel- air ratio is **0.017** kg / kg of air. The turbine efficiency is **90 %**. Find out (a) the maximum temperature in the cycle (b) actual work of turbine (c) actual work of compressor per kg of air compressed (d) thermal efficiency of the plant. Take:

(i) Specific heat of air C_P = **1.005** kJ /kg-K and **γ = 1.4**

(ii) Specific heat for product of combustion gas C_{Pg} = **1.147** kJ /kg-K and **γ = 1.3** [11 M]

Q.6 For a single stage single acting air compressor, actual volume of air taken in is **10m^3/min**, initial intake pressure **1.013** bar, initial temperature **27^{0}C**, Final pressure **900** kN/m^2. Clearance is 6 % of stroke volume. Stroke to bore ratio (L: D) **=1.25** and compressor is running at **400** rpm, take **n=1.3**. Determine (a) volumetric efficiency (b) swept volume in m^3/min (c) cylinder dimensions (d) Indicator Power of the compressor [11 M]

Q.7 The following results were obtained in a boiler trial:

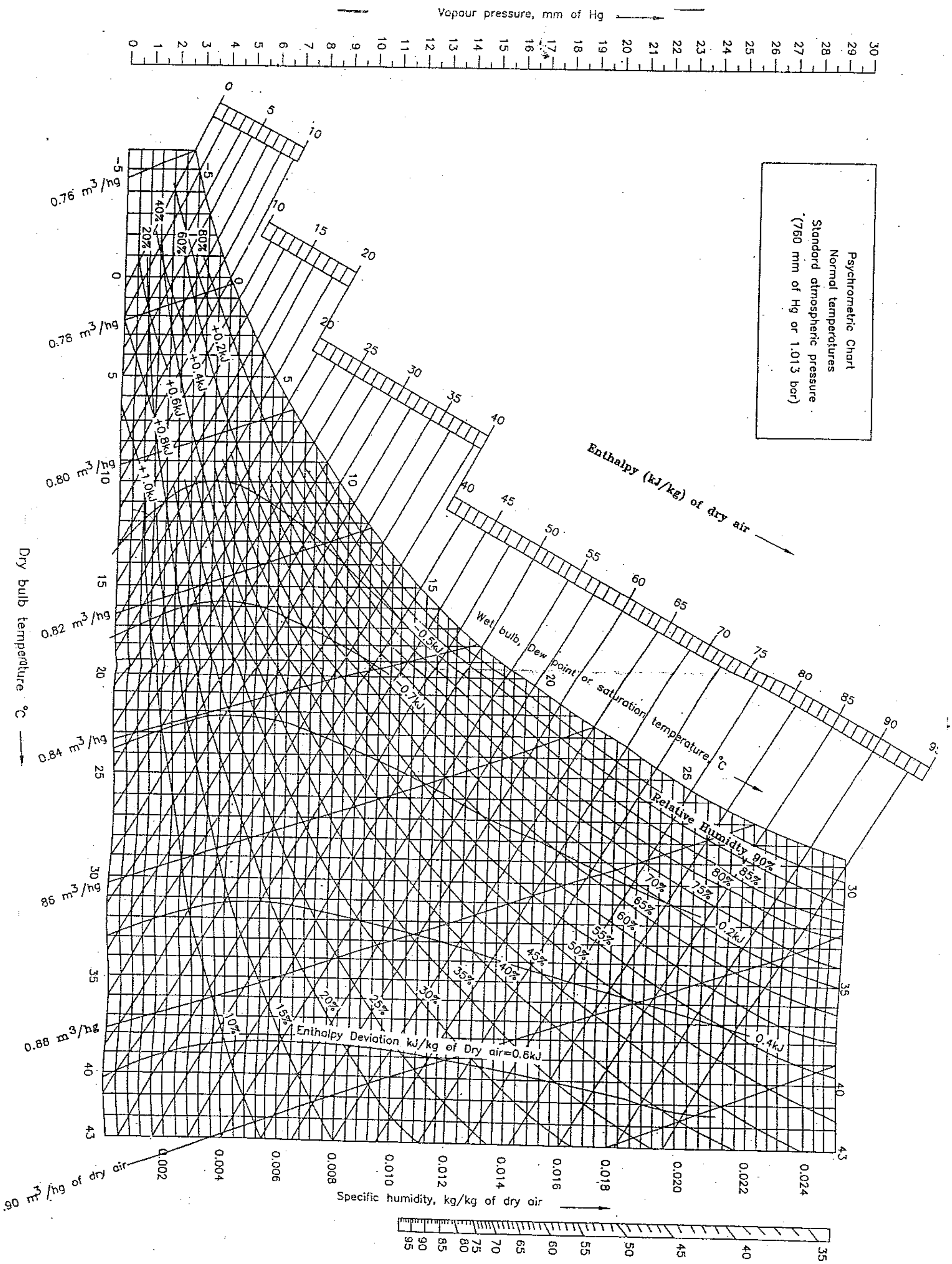
➢ Steam pressure and quality	:**8** bar and **0.95** dry
➢ Feed water	:**750** kg / hr at **25^{0}C**
➢ Coal consumption	:**100** kg/hr
➢ Calorific value of coal	:**27300** kJ /kg
➢ Generation of ash collected from the furnace	:**8** kg /hr
➢ Calorific value of ash	:**2815** kJ /kg
➢ Mass of flue gases	:**17** kg/kg of coal
➢ Flue gas temperature	:**325^0 C**
➢ Ambient air temperature	: **15^0 C**
➢ specific heat of air (c_P)	:**1.0** kJ /kg-K

Calculate (a) Boiler efficiency (b) % age of heat loss to the flue gas (c) % age of heat loss to the ashes (d) % age of heat loss to unaccounted for. [11 M]

Q.8 **[a]** List out the advantages of combined cycle power generation? [3 M]

[b] Briefly explain about integrated gasification power generation [IGCC] with neat sketch [5 M]

[PTO]



Vapour pressure, mm of Hg
Psychrometric Chart
Normal temperatures
Standard atmospheric pressure
(760 mm of Hg or 1.013 bar)
Enthalpy (kJ/kg) of dry air
Wet bulb, Dew point or saturation temperature, °C
Relative Humidity 90%
Enthalpy Deviation kJ/kg of Dry air=0.6kJ
Dry bulb temperature °C
0.76 m3/hg
0.78 m3/hg
0.80 m3/hg
0.82 m3/hg
0.84 m3/hg
86 m3/hg
0.88 m3/hg
.90 m3/hg of dry air
Specific humidity, kg/kg of dry air

BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI, DUBAI CAMPUS

I SEMESTER 2012-2013

Test No.2 (Open Book)

Year : II-MECHANICAL	**Section: 1 and 2**	**Date : 18.11.2012**
Course No. : ME F214	**Course Title : APPLIED THERMODYNAMICS**	
Duration : 50Min	**Marks: 40**	**Weightage : 20 %**

Q.1 A food storage locker requires a refrigeration system of **2400 kJ/min** capacity at an evaporator temperature of **263 K** and a condenser temperature of **303 K**. The refrigerant used is freon-12 and is sub-cooled by **6°C** before entering the expansion valve and vapour is superheated by **7°C** before leaving the evaporator coil as shown in Fig.1. The compression of refrigerant is reversible adiabatic. The refrigeration compressor is two-cylinder single-acting with stroke equal to **1.25** times the bore and operates at **1000 r.p.m**. Assume the enthalpy of sub-cooled **($h_{f4'}$)** by the refrigerant is **57.19 kJ/kg**. [20 M]

Take: Liquid specific heat = **1.235 kJ/kg K** ; Vapour specific heat = **0.733 kJ/kg K.**

Determine: (i) Refrigerating effect per kg.

(ii) Mass of refrigerant to be circulated per minute.

(iii) Theoretical piston displacement per minute.

(iv) Theoretical power required to run the compressor, in kW.

(v) Heat removed through condenser per min.

(vi) Theoretical bore and stroke of compressor.

Properties of freon-12

Saturation temp, K	*Absolute pressure, bar*	*Specific volume of vapour, m^3/kg*	*Enthalpy, kJ/kg*		*Entropy, kJ/kg K*	
			Liquid	*Vapour*	*Liquid*	*Vapour*
263	2.19	0.0767	26.9	183.2	0.1080	0.7020
303	7.45	0.0235	64.6	199.6	0.2399	0.6854

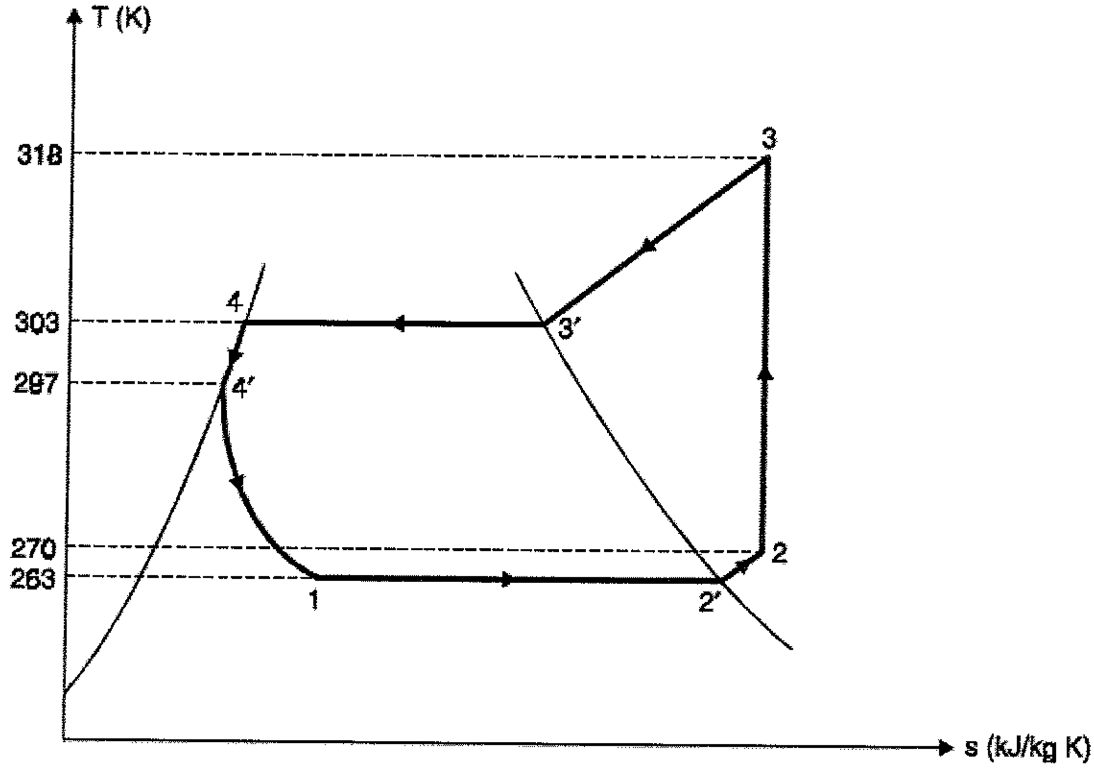


Fig.1

Q.2. The air enters the compressor of an open cycle constant pressure gas turbine at a pressure of **1 bar** and temperature of **20°C**. The pressure of the air after compression is **4 bar**. Maximum cycle temperature is **657 ^{0}C** and the hot gas after expansion taking from turbine is rejected to atmosphere pressure. The isentropic efficiencies of compressor and turbine are **80 %** and **85 %** respectively. If flow rate of air is **3.0 kg/s**, find:

(i) Temperature at the salient points of the cycle

(ii) Air-Fuel ratio

(iii) Power developed by the turbine and compressor per kg of air

(iv) Thermal efficiency of the cycle.

Assume **c_p = 1.0 kJ/kg k** and **γ = 1.4** for air and gases.

Calorific value of fuel = **41800 kJ/kg**. [20 M]

BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI, DUBAI CAMPUS

I SEMESTER 2012-2013

Test No.1 (Closed Book)

Year : II-MECHANICAL	**Section: 1 and 2**	**Date : 30.09.2012**
Course No. : ME F214	**Course Title : APPLIED THERMODYNAMICS**	
Duration : 50Min	**Marks: 25**	**Weightage : 25 %**

Notes: (i) *answer all the questions* (ii) *Draw neat sketches wherever necessary*

(iii) *Make suitable assumptions if required and clearly state them (iv) Steam table will be provided*

Q.1 List out at least 4 points comparing Otto cycle and Diesel cycle. [4 M]

Q.2 A four stroke engine working on Otto-cycle has a swept volume of **0.1 m^3**. The compression ratio is **7**. The condition at the start of the cycle is pressure **1** bar and temperature **90 ^{0}C**. The heat addition at constant volume is **100kJ/ cycle**. Find ideal efficiency, mean effective pressure, temperature and pressure at key points in the cycle. Assume air as working substance with **C_v = 0.718 kJ/kg-k**, **R** for air = **0.287 kJ/kg-k** and **γ = 1.4** [10.5 M]

Q.3 A diesel engine operating on the air-standard diesel cycle has **six** cylinders of **100mm** bore and **120 mm** stroke. The engine speed is **1800 rpm**. At the beginning of compression the pressure and temperature of air are **1.03 bar** and **35^{0}C**. If the clearance volume is **1/8** of the stroke volume, if the air is heated to 1500 ^{0}C

Calculate (i) pressure and temperature at the salient points of the cycle (ii) compression ratio (iii) efficiency of the cycle and (iv) mass of air drawn into the cylinder. Assume C_p and C_v of air to be **1.004 kJ/kg-k** and **0.717 kJ/kg-k** respectively. Take: **R** for air = **0.287 kJ/kg-k** and **γ = 1.4** [10.5 M]

VERSION; A

BITS Pilani, Dubai Campus

Dubai International Academic City, Dubai, U.A.E

II Year I Semester 2012-2013 [Mechanical]

Quiz.2 (Closed Book)

Course No. ME C 211 **Course Title:** Applied Thermodynamics **Weightage:** 7 %

Date: 12-12-2012 **Max.Marks:** 14 **Duration:** 20 min.

STUDENT NAME:---**I.D No:**------------------------------------

Q.No	1	2	3	4	5	6	7	8	9	10	11	12	13
Answer													

Q.1.In fire tube boiler **[1 M]**

[A] The hot products of combustion passes through the tubes and water around it

[B] Water passes through the tubes and hot products of combustion around it

[C]Forced circulation occurs [D] None of the above

Q.2 Fire tube boiler is **[1 M]**

[A] Lancashire boiler [B] Cochran boiler [C] Locomotive boiler

[D] All of the above

Q.3. A Babcock-Wilcox boiler is classified as a water tube boiler, because **[1 M]**

[A] It has a large bank of tubes and a steam drum

[B] Water passes through tubes and hot gas around the tubes

[C] Water evaporates in the drums

[D] Super heater is mounted directly above the bank of tubes

Q.4. For the same diameter and thickness of tube, fired tube boiler as compared to water tube boiler has **[1 M]**

[A] More heating surface [B] less heating surfece

[C] same heating surfece [D] None of the above

Q.5.The output of a boiler is normally stated as **[1 M]**

[A] Evaporation capacity in tonnes of steam that can be produced from and at 100^0 C

[B] Weight of steam actually produced at rated pressure in tonnes hour

[C] Boiler horse power

[D] Weight of steam produced per kg of fuel

Q.6.Equivalent evaporation is defined as **[1 M]**

[A] Ratio of heat actually used in producing steam to the heat liberated in the furnance

[B] Amounted of water evaporated as dry saturated steam in kg per kg of coal burnt

[C] Evaporation of water from and at 100^0C into dry saturated steam

[D] Evaporation of 15.653 kg of water per hour from and at 100^0C.

Q.7.The ratio of heat actually used in raising steam to the heat liberated in the boiler furnace by the combustion of fuel is called **[1 M]**

[A] Equivalent evaporation [B] Generation factor

[C]Factor of evaporation [D] Boiler efficiency

Q.8.The steam in boiler drum is always **[1 M]**

[A] Wet [B] Dry [C] Superheater [D] Wet and dry

Q.9 In boiler, the feed water supplied per hour is 205 kg while coal fired per hour is 23 kg. Net enthalpy rise per kg of water is 145 kJ for conversion to steam. If the calorific value of the coal is 2050 kJ/kg, then boiler efficiency will be **[1 M]**

[A] 62 % [B] 63 % [C] 61 % [D] 60%

Q.10. Blow down is necessary on boilers, because **[1 M]**

1.The boiler water level is lowerd rapidly in case it accidentaly rise to high

2.The precipitated sediment or sludge is removed while the boiler is in service

3. The concentration of suspended solids in the boiler is controlled

Of these statements

[A] 1,2 and 3 are correct [B] 1 and 2 are correct

[C] 3 alone is correct [D] 1and 3 are correct

Q.11. Which one of the following sequences indicates the correct oredr of flue gas flow in the steam power plant lay out.? **[1 M]**

[A] economiser, air preheater, superheater

[B] air preheater, Economiser, superheater

[C] superheater, economiser, air preheater

[D] economiser, superheater, air preheater

Q.12 A boiler producing 2000 kg/hr of steam with enthalpy content of 2426 kJ/kg from feed water at temperature 40^0C (liquid enthalpy =168 kJ/kg). Find equivalent evaporation (kg/hr) **[1.5 M]**

Answer

Q13. In oil fuel with a calorific value of 44700 kJ is burnt in a boiler with air-fuel ratio as 20:1. Calculate the maximum temperature attained in the furnace of the boiler. Assume that whole of the heat of combustion is given to the products of combustion and hot gas specific heat is 1.08 KJ/kg-K. Take boiler room temperature as 38 ^0C. **[1.5 M]**

Answer

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VERSION; A

BITS Pilani, Dubai Campus

Dubai International Academic City, Dubai, U.A.E

II Year I Semester 2012-2013 [Mechanical]

Quiz.1 (Closed Book)

Course No. ME C 211 **Course Title:** Applied Thermodynamics **Weightage:** 8 %

Date: 24-10-2012 **Max.Marks:** 16 **Duration:** 20 min.

STUDENT NAME:---**I.D No:**------------------------------------

Q.No	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Answer										

Q.1. Rankine cycle comprises of ______________________________ **[1 M]**

(a) Two isentropic processes and two constant volume processes

(b) Two isentropic processes and two constant pressure processes

(c) Two isothermal processes and two constant pressure processes

(d) None of the above

Q.2 In Rankine cycle the work output from the turbine is given by **[1 M]**

(a) Change of Internal energy between inlet and outlet

(b) Change of enthalpy between inlet and outlet

(c) Change of entropy between inlet and outlet

(d) Change of temperature between inlet and outlet

Q.3 In Rankine cycle efficiency of a good steam power plant may be in the range of **[1 M]**

(a) 15 to 20 % (b) 35 to 45 % (c) 70 to 80 % (d) 90 to 95 %

Q.4. Critical temperature of Steam is ___________________ **[1 M]**

(a) 313 ^{0}C (b) 347^{0}C (c) 375^{0}C (d) 409^{0}C

Q.5. Which form of the vapour has a behavior close to that of a gas? **[1 M]**

.(a) wet vapour only (b) dry and saturated vapour (c) wet and dry vapour

(d) super heated vapour

Q.6. The heat observed by water at its saturation temperature to get converted in to dry steam at the same temperature is called **[1 M]**

(a) sensible heat (b) specific heat (c) latent heat (d)total heat

Q.7. A wet vapour can be completely specified by its________ **[1 M]**

(a) pressure (b) temperature (c) pressure and dryness fraction

(d) pressure and temperature

Q.8. which of the following parameter decreases at the pressure of steam is raised. **[1 M]**

(a) saturation temperature (b)specific volume (c) sensible heat

(d) latent heat of vaporization

Q.9. In Rankine cycle the work output from the turbine is given by_________ **[1 M]**

[a] Change in internal energy between inlet and outlet

[b] Change of entropy between inlet and outlet

[c] Change of temperature between inlet and outlet

[d] Change in enthalpy between inlet and outlet

Q.10. In steam power plant power output from the turbine is 1665 kW and pump work is 15 kW. Heat input to the plant is 3000 kW. Find the efficiency of the power plant. **[1 M]**

[a] 55 % [b] 56 % [c] 54 % [d] 53 %

Q.11. In a steam turbine steam at 20 bar is expanded to 0.08 bar. It then enters a condenser, where it is condensed to saturated liquid water. The pump feeds back the water into the boiler. Assume ideal processes; find pump work per kg of steam. Take specific volume = 0.00108 m^3/kg **[1.5 M]**

Answer

Q.12. In a steam power cycle, the steam supply is at 15 bar and dry and saturated. The condenser pressure is 0.4 bar. Calculate the Carnot efficiency of the cycle. Assume the following values. **[1.5 M]**

At 15 bar: $t_s = 198.3°C$

At 0.4 bar: $t_s = 75.9°C$

Answer

Q.13. The condensate exit from the condenser contains 10 kg of water at 90°C and it is stored in the hot well tank. If 8 kg of the water is in the liquid form and the rest is in the vapor form, determine (*a*) the pressure in the tank and (*b*) the volume of the tank. **[3 M]**

Temp(^{0}C)	Pressure (Bar)	Sp.vol m^3/kg		Sp.enthalpy kJ/kg			Sp.entropy kJ/kg		
t	p	v_f	V_g	h_f	h_{fg}	h_g	s_f	S_{fg}	s_g
90	0.70109	0.001036	2.3613	376.9	2283.2	2660.1	1.193	6.287	7.480

Answer

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