

每題 25 分, 計四題共 100 分

1. (a) Two-liquid-in-glass thermometers have Celsius and Fahrenheit scales, respectively. Both thermometers are used to measure the temperature of an object. If each thermometer indicates the same numerical reading, what is the temperature, in Kelvins? (15%)

(b). A combustion experiment is performed by burning a mixture of fuel and air in a constant-volume "bomb" surrounded by a water bath. During the experiment the temperature of the water is observed to rise. If we regard the mixture of fuel and air as the system, please answer the following questions and explain why: (10%)

(i) Has heat been transferred?

(ii) Has work been done?

(iii) What is the sign of ΔU ?

2. A tank of air at 25 psia and 100°F has a volume of 29ft^3 . Heat is transferred to the air from a reservoir at 1500°R until the temperature of the air in the tank is 660°F . The surrounding atmosphere is at 60°F and 14.7 psia.

Please calculate:

(a) the initial and final availability of the air in BTUs.

(b) the maximum useful work associated with the process in BTUs.

(c) the irreversibilities (internal and external)

Note:

$$C_p \text{ of air is } 0.24 \text{ Btu/lb}^\circ\text{R}$$

$$R_{\text{univ}} = 1.986 \text{ Btu/lb}_{\text{mol}}^\circ\text{R}$$

3. The operating Conditions for a gas-turbine power plant shown in Fig.1 are summarized in the table below. Atmospheric air enters the compressor at a rate of 25 kg/s. The power required to drive the compressor is supplied by the turbine. The net power output from the plant is used to drive an electric generator. please calculate
- the power input to the compressor
 - the Net power produced by the power plant
 - the heat-transfer rate in the heat exchanger.
 - the entropy change during this cycle.
- (e) please discuss the case if the working medium is changed from air to steam. What will be the major difference?

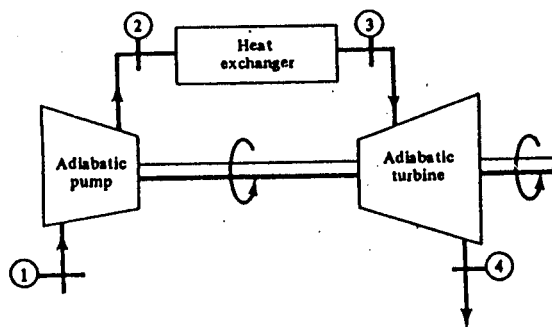


Fig.1. Gas-turbine power plant

LOCATION	PRESSURE, kPa	TEMPERATURE, °C
①	100	27
②	550	262
③		
④	170	477

OTHER DATA
 Mass flow rate of air = 10 kg/s
 Power input to compressor is 60% of the total power output of the turbine.
 Negligible pressure drop through heat exchanger

4.

100 m³/min of dry air at 32°C and 1 bar is mixed with a stream of hydrogen at 127°C and 1 bar to form a mixed stream at 47°C and 1 bar. The mixing occurs adabatically and at steady state. Kinetic and potential energy effects can be ignored. Determine (a) the mass flow rates of the dry air and hydrogen, in kg/min, (b) the time rate of entropy production, in kJ/K per minute.

- Given:
1. molecular weight of air and hydrogen are 28.97 and 2.018, respectively;
 2. universal gas constant $\bar{R}=8.314$ kJ/kmol/K;
 3. Tables of Ideal Gas Properties.

TABLE A-1 Ideal Gas Properties of Air

T (K), h and u (kJ/kg), s° (kJ/kg · K)											
T	h	p _r	u	v _r	s°	T	h	p _r	u	v _r	s°
200	199.97	0.3363	142.56	1707.	1.29559	450	451.80	5.775	322.62	223.6	2.11161
210	209.97	0.3987	149.69	1512.	1.34444	460	462.02	6.245	329.97	211.4	2.13407
220	219.97	0.4690	156.82	1346.	1.39105	470	472.24	6.742	337.32	200.1	2.15604
230	230.02	0.5477	164.00	1205.	1.43557	480	482.49	7.268	344.70	189.5	2.17760
240	240.02	0.6355	171.13	1084.	1.47824	490	492.74	7.824	352.08	179.7	2.19876
250	250.05	0.7329	178.28	979.	1.51917	500	503.02	8.411	359.49	170.6	2.21952
260	260.09	0.8405	185.45	887.8	1.55848	510	513.32	9.031	366.92	162.1	2.23993
270	270.11	0.9590	192.60	808.0	1.59634	520	523.63	9.684	374.36	154.1	2.25997
280	280.13	1.0889	199.75	738.0	1.63279	530	533.98	10.37	381.84	146.7	2.27967
285	285.14	1.1584	203.33	706.1	1.65055	540	544.35	11.10	389.34	139.7	2.29906
290	290.16	1.2311	206.91	676.1	1.66802	550	554.74	11.86	396.86	133.1	2.31809
295	295.17	1.3068	210.49	647.9	1.68515	560	565.17	12.66	404.42	127.0	2.33685
300	300.19	1.3860	214.07	621.2	1.70203	570	575.59	13.50	411.97	121.2	2.35531
305	305.22	1.4686	217.67	596.0	1.71865	580	586.04	14.38	419.55	115.7	2.37348
310	310.24	1.5546	221.25	572.3	1.73498	590	596.52	15.31	427.15	110.6	2.39140
315	315.27	1.6442	224.85	549.8	1.75106	600	607.02	16.28	434.78	105.8	2.40902
320	320.29	1.7375	228.42	528.6	1.76690	610	617.53	17.30	442.42	101.2	2.42644
325	325.31	1.8345	232.02	508.4	1.78249	620	628.07	18.36	450.09	96.92	2.44356
330	330.34	1.9352	235.61	489.4	1.79783	630	638.63	19.84	457.78	92.84	2.46048
340	340.42	2.149	242.82	454.1	1.82790	640	649.22	20.64	465.50	88.99	2.47716
350	350.49	2.379	250.02	422.2	1.85708	650	659.84	21.86	473.25	85.34	2.49364
360	360.58	2.626	257.24	393.4	1.88543	660	670.47	23.13	481.01	81.89	2.50985
370	370.67	2.892	264.46	367.2	1.91313	670	681.14	24.46	488.81	78.61	2.52589
380	380.77	3.176	271.69	343.4	1.94001	680	691.82	25.85	496.62	75.50	2.54175
390	390.88	3.481	278.93	321.5	1.96633	690	702.52	27.29	504.45	72.56	2.55731
400	400.98	3.806	286.16	301.6	1.99194	700	713.27	28.80	512.33	69.76	2.57277
410	411.12	4.153	293.43	283.3	2.01699	710	724.04	30.38	520.23	67.07	2.58810
420	421.26	4.522	300.69	266.6	2.04142	720	734.82	32.02	528.14	64.53	2.60319
430	431.43	4.915	307.99	251.1	2.06533	730	745.62	33.72	536.07	62.13	2.61803
440	441.61	5.332	315.30	236.8	2.08870	740	756.44	35.50	544.02	59.82	2.63280

TABLE A-2 Ideal Gas Properties of Hydrogen, H₂

T(K), \bar{h} and \bar{u} (kJ/kmol), \bar{s}° (kJ/kmol · K)

$[\bar{h}_f^\circ = 0 \text{ kJ/kmol}]$

T	\bar{h}	\bar{u}	\bar{s}°	T	\bar{h}	\bar{u}	\bar{s}°
0	0	0	0	1440	42,808	30,835	177.410
260	7,370	5,209	126.636	1480	44,091	31,786	178.291
270	7,657	5,412	127.719	1520	45,384	32,746	179.153
280	7,945	5,617	128.765	1560	46,683	33,713	179.995
290	8,233	5,822	129.775	1600	47,990	34,687	180.820
298	8,468	5,989	130.574	1640	49,303	35,668	181.632
300	8,522	6,027	130.754	1680	50,662	36,654	182.428
320	9,100	6,440	132.621	1720	51,947	37,646	183.208
340	9,680	6,853	134.378	1760	53,279	38,645	183.973
360	10,262	7,268	136.039	1800	54,618	39,652	184.724
380	10,843	7,684	137.612	1840	55,962	40,663	185.463
400	11,426	8,100	139.106	1880	57,311	41,680	186.190
420	12,010	8,518	140.529	1920	58,668	42,705	186.904
440	12,594	8,936	141.888	1960	60,031	43,735	187.607
460	13,179	9,355	143.187	2000	61,400	44,771	188.297
480	13,764	9,773	144.432	2050	63,119	46,074	189.148
500	14,350	10,193	145.628	2100	64,847	47,386	189.979
520	14,935	10,611	146.775	2150	66,584	48,708	190.796
560	16,107	11,451	148.945	2200	68,328	50,037	191.598
600	17,280	12,291	150.968	2250	70,080	51,373	192.385
640	18,453	13,133	152.863	2300	71,839	52,716	193.159
680	19,630	13,976	154.645	2350	73,608	54,069	193.921
720	20,807	14,821	156.328	2400	75,383	55,429	194.669
760	21,988	15,669	157.923	2450	77,168	56,798	195.403
800	23,171	16,520	159.440	2500	78,960	58,175	196.125
840	24,359	17,375	160.891	2550	80,755	59,554	196.837
880	25,551	18,235	162.277	2600	82,558	60,941	197.539
920	26,747	19,098	163.607	2650	84,386	62,335	198.229
960	27,948	19,966	164.884	2700	86,186	63,737	198.907
1000	29,154	20,839	166.114	2750	88,008	65,144	199.575
1040	30,364	21,717	167.300	2800	89,838	66,558	200.234
1080	31,580	22,601	168.449	2850	91,671	67,976	200.885
1120	32,802	23,490	169.560	2900	93,512	69,401	201.527
1160	34,028	24,384	170.636	2950	95,358	70,831	202.157
1200	35,262	25,284	171.682	3000	97,211	72,268	202.778
1240	36,502	26,192	172.698	3050	99,065	73,707	203.391
1280	37,749	27,106	173.687	3100	100,926	75,152	203.995
1320	39,002	28,027	174.652	3150	102,793	76,604	204.592
1360	40,263	28,955	175.593	3200	104,667	78,061	205.181
1400	41,530	29,889	176.510	3250	106,545	79,523	205.765