



higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T320(E)(A6)T

NATIONAL CERTIFICATE

CHEMICAL PLANT OPERATION N5

(8050015)

6 April 2018 (X-Paper)

09:00–12:00

REQUIREMENTS: Steam tables
Periodic table

Calculators may be used.

This question paper consists of 5 pages, 1 steam table and 1 periodic table.

DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA
NATIONAL CERTIFICATE
CHEMICAL PLANT OPERATIONS N5
TIME: 3 HOURS
MARKS: 100

INSTRUCTIONS AND INFORMATION

1. Answer ALL the questions.
 2. Read ALL the questions carefully.
 3. Number the answers according to the numbering system used in this question paper.
 4. Write neatly and legibly.
-

QUESTION 1

Define each of the following:

- | | | |
|-----|----------------------------|-----|
| 1.1 | Heat of reaction | (2) |
| 1.2 | Saturation temperature | (3) |
| 1.3 | Superheated steam | (2) |
| 1.4 | Standard heat of formation | (3) |
| 1.5 | A tie substance | (3) |
| 1.6 | Kopp's rule | (2) |
- [15]**

QUESTION 2

Give ONE word or term for each of the following descriptions. Write only the word or term next to the question number (2.1–2.5) in the ANSWER BOOK.

- | | | |
|-----|--|--------------------|
| 2.1 | Energy of an object due to its state of movement or velocity | |
| 2.2 | The amount of heat required to raise the temperature of one gram of water from 14,5 °C to 15,5 °C | |
| 2.3 | A piece of equipment, generally driven by an electric motor, which puts an object in rotation around a fixed axis applying a force perpendicular to the axis | |
| 2.4 | The diameter for which ONE half of the inlet particles are separated by mass and the other half retained by air | |
| 2.5 | A turbine in which only part of the pressure drop occurs in the nozzle | (5 × 1) [5] |

QUESTION 3

- 3.1 One of the techniques for producing hydrogen for various refining and petrochemical operations is to react methane and ethane with steam in the presence of a nickel catalyst. The analysis on a dry basis of the gases leaving such a reactor is as follows:

$\text{CH}_4 = 4,6 \text{ mol\%}$, $\text{C}_2\text{H}_6 = 2,3 \text{ mol\%}$, $\text{CO} = 18,6 \text{ mol\%}$ $\text{CO}_2 = 4,6 \text{ mol\%}$ and $\text{H}_2 = 69,7 \text{ mol\%}$

What is the molar ratio of these TWO gases in the feed? (11)

- 3.2 Draw a labelled diagram of the impulse reaction turbine. (6)

- 3.3 State the criteria for good combustion of fuels. (3)

[20]

QUESTION 4

- 4.1 Draw a Van't Hoff box. (5)

- 4.2 Discuss the operation of the cyclone. (5)

- 4.3 State the procedure used for solving material balance problems. (5)

[15]

QUESTION 5

- 5.1 A particular liquid fuel blend should contain 35 mol% C_8 and 65 mol% C_{12} hydrocarbons. To blend the particular liquid fuel, the following light and heavy fuel oil are available:

HYDROCARBON	LIGHT FUEL	HEAVY FUEL
C_8	70 mol%	25 mol%
C_{12}	30 mol%	75 mol%

Calculate the amount of light fuel oil and the amount of heavy fuel oil that must be blended to produce 100 kg/mol of the desired product. (10)

- 5.2 Draw a fully labelled diagram of the tubular centrifuge. (7)

- 5.3 Define *Hess's law of heat of summation*. (3)

[20]

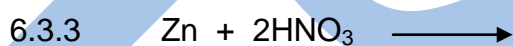
QUESTION 6

6.1 State FIVE uses of sulphuric acid. (5)

6.2 Write down a chemical balanced reaction for the formation of SO_2 . (3)

6.3 Nitric acid reacts with most metals and liberates H_2 gas.

Complete the following chemical reactions given below:



(3 × 2) (6)

6.4 State SIX uses of nitric acid. (6)

6.5 What should you bear in mind to maximise the chemical conversion of SO_2 to SO_3 ? (5)

[25]

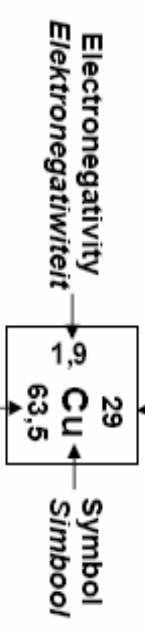
TOTAL: 100

p	t_s	v_g	h_f	h_{fg}	h_g	s_f	s_g	p	t_s	v_g	h_f	h_{fg}	h_g	s_f	s_g
kPa	°C	m ³ /kg	kJ/kg	kJ/kg	kJ/kg	kJ/kg·K	kJ/kg·K	kPa	°C	m ³ /kg	kJ/kg	kJ/kg	kJ/kg	kJ/kg·K	kJ/kg·K
10	7,0	129,20	29	2 485	2 514	0,106	8,977	75	91,8	2,217	385	2 279	2 664	1,213	7,457
1,6	13,0	87,98	55	2 471	2 528	0,196	8,829	80	93,5	2,087	392	2 274	2 666	1,233	7,435
2,0	17,5	67,01	74	2 460	2 534	0,261	8,725	85	95,2	1,972	399	2 270	2 669	1,252	7,415
2,5	21,1	54,26	89	2 452	2 541	0,312	8,644	90	96,7	1,869	405	2 266	2 671	1,270	7,395
3,0	24,1	45,67	101	2 445	2 546	0,354	8,579	95	98,2	1,777	412	2 262	2 674	1,287	7,377
3,5	26,7	39,48	112	2 439	2 551	0,391	8,523	100	99,6	1,694	418	2 258	2 676	1,303	7,360
4,0	29,0	34,80	121	2 433	2 554	0,423	8,476	110	102,3	1,549	429	2 251	2 683	1,333	7,328
4,5	31,0	31,14	130	2 428	2 558	0,451	8,434	120	104,8	1,428	439	2 244	2 688	1,361	7,300
5,0	32,9	28,19	138	2 424	2 562	0,476	8,396	130	107,1	1,325	449	2 238	2 693	1,387	7,272
5,5	34,6	25,77	145	2 420	2 565	0,500	8,362	140	109,3	1,236	458	2 232	2 690	1,411	7,247
6,0	36,2	23,74	152	2 416	2 568	0,521	8,331	150	111,4	1,159	467	2 226	2 693	1,434	7,223
6,5	37,7	22,02	158	2 413	2 571	0,541	8,303	160	113,3	1,091	475	2 221	2 696	1,455	7,202
7,0	39,0	20,53	163	2 410	2 573	0,559	8,277	170	115,2	1,031	483	2 216	2 699	1,475	7,181
7,5	40,3	19,24	169	2 406	2 575	0,576	8,252	180	116,9	0,977 2	491	2 211	2 702	1,494	7,162
8,0	41,6	18,10	174	2 403	2 577	0,593	8,230	190	118,6	0,929 0	498	2 206	2 704	1,513	7,144
8,5	42,7	17,10	179	2 401	2 580	0,608	8,208	200	120,2	0,885 9	505	2 202	2 707	1,530	7,127
9,0	43,8	16,20	183	2 398	2 581	0,622	8,188	210	121,8	0,845 9	511	2 197	2 708	1,547	7,111
9,5	44,8	15,40	188	2 395	2 585	0,636	8,169	220	123,3	0,809 8	518	2 193	2 711	1,563	7,095
10	45,8	14,67	192	2 393	2 585	0,649	8,151	230	124,7	0,776 8	524	2 189	2 713	1,578	7,080
11	47,7	13,42	200	2 388	2 589	0,674	8,118	240	126,1	0,746 5	530	2 185	2 715	1,593	7,066
12	49,5	12,36	207	2 384	2 591	0,696	8,087	250	127,4	0,718 4	535	2 181	2 718	1,607	7,052
13	51,1	11,47	214	2 380	2 594	0,717	8,059	260	128,4	0,692 5	541	2 177	2 718	1,621	7,039
14	52,6	10,69	220	2 377	2 597	0,737	8,033	270	130,0	0,668 4	546	2 174	2 720	1,634	7,026
15	54,0	10,02	226	2 373	2 599	0,755	8,009	280	131,2	0,646 0	551	2 170	2 721	1,647	7,014
16	55,3	9,433	232	2 370	2 602	0,772	7,987	290	132,4	0,625 1	557	2 167	2 724	1,660	7,002
17	56,6	8,911	237	2 367	2 606	0,788	7,966	300	133,5	0,605 6	561	2 163	2 724	1,672	6,991
18	57,8	8,445	242	2 361	2 608	0,804	7,946	310	134,7	0,587 7	566	2 160	2 726	1,683	6,980
19	59,0	8,027	247	2 358	2 610	0,818	7,927	320	135,8	0,570 0	571	2 157	2 728	1,695	6,969
20	60,1	7,650	252	2 355	2 612	0,832	7,909	330	136,8	0,553 8	576	2 154	2 730	1,706	6,959
21	61,1	7,307	256	2 353	2 613	0,845	7,893	340	137,9	0,538 5	580	2 150	2 731	1,717	6,949
22	62,2	6,995	260	2 351	2 615	0,858	7,876	350	138,9	0,524 0	584	2 147	2 731	1,727	6,939
23	63,1	6,709	264	2 349	2 615	0,870	7,861	360	139,9	0,510 3	589	2 144	2 733	1,738	6,930
24	64,1	6,447	268	2 346	2 617	0,882	7,846	370	140,8	0,497 4	593	2 141	2 734	1,748	6,921
25	65,0	6,204	272	2 344	2 618	0,893	7,832	380	141,8	0,485 1	597	2 139	2 736	1,757	6,912
26	65,9	5,980	276	2 344	2 620	0,904	7,819	390	142,7	0,473 4	601	2 136	2 737	1,767	6,903
27	66,7	5,772	279	2 342	2 621	0,915	7,806	400	143,6	0,462 2	605	2 133	2 738	1,776	6,894
28	67,6	5,579	283	2 340	2 623	0,925	7,793	410	144,5	0,451 6	609	2 130	2 739	1,786	6,886
29	68,3	5,398	286	2 338	2 625	0,935	7,781	420	145,3	0,441 5	612	2 128	2 740	1,795	6,878
30	69,1	5,229	289	2 336	2 625	0,944	7,770	430	146,3	0,431 8	616	2 125	2 741	1,803	6,870
32	70,6	4,922	296	2 332	2 628	0,962	7,747	440	147,1	0,422 6	620	2 122	2 742	1,812	6,862
34	72,0	4,650	302	2 329	2 631	0,980	7,727	450	147,9	0,413 8	624	2 120	2 744	1,820	6,855
36	73,4	4,408	307	2 326	2 633	0,996	7,707	460	148,7	0,405 3	627	2 117	2 744	1,829	6,847
38	74,7	4,190	313	2 322	2 635	1,011	7,688	470	149,5	0,397 2	634	2 112	2 745	1,837	6,840
40	75,9	3,993	318	2 319	2 635	1,026	7,671	480	150,3	0,389 4	637	2 110	2 746	1,845	6,833
45	78,7	3,576	330	2 312	2 637	1,060	7,631	490	151,1	0,381 9	637	2 107	2 747	1,853	6,826
50	81,4	3,240	341	2 305	2 642	1,091	7,595	500	151,8	0,374 7	640	2 103	2 747	1,860	6,819
55	83,7	2,964	351	2 299	2 650	1,119	7,562	520	153,3	0,361 1	647	2 103	2 750	1,875	6,806
60	86,0	2,732	360	2 294	2 654	1,145	7,533	540	154,8	0,348 5	653	2 098	2 751	1,890	6,793
65	88,0	2,535	369	2 288	2 657	1,170	7,506	560	156,2	0,336 7	659	2 094	2 753	1,904	6,781
70	90,0	2,365	377	2 283	2 660	1,192	7,480	580	157,5	0,325 7	665	2 089	2 754	1,918	6,769

THE PERIODIC TABLE OF ELEMENTS
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1 (i)	2 (ii)	3	4	5	6	7	8	9	10	11	12	13 (iii)	14 (iv)	15 (v)	16 (vi)	17 (vii)	18 (viii)
1 H 1,01	4 Be 9,01	21 Sc 44,96	22 Ti 47,88	23 V 50,94	24 Cr 51,99	25 Mn 54,94	26 Fe 55,85	27 Co 58,93	28 Ni 58,71	29 Cu 63,55	30 Zn 65,38	31 Ga 69,72	32 Ge 72,64	33 As 74,92	34 Se 78,96	35 Br 79,90	36 Kr 83,80
3 Li 6,94	9 B 10,81	39 K 39,10	40 Ca 40,08	41 Nb 92,91	42 Mo 95,94	43 Tc 98,91	44 Ru 101,07	45 Rh 102,91	46 Pd 106,42	47 Ag 107,87	48 Cd 112,41	49 In 114,82	50 Sn 118,71	51 Sb 121,76	52 Te 127,60	53 I 126,91	54 Xe 131,29
11 Na 22,99	12 Mg 24,31	37 Rb 85,47	38 Sr 87,62	55 Cs 132,91	56 Ba 137,33	87 Fr 223,02	88 Ra 226,03	89 Ac	89 La 138,91	90 Ce 140,12	91 Pr 140,91	92 Nd 144,24	93 Pm	94 Sm 150,36	95 Eu 151,96	96 Gd 157,25	97 Tb 158,93
19 K 39,10	20 Ca 40,08	21 Sc 44,96	22 Ti 47,88	23 V 50,94	24 Cr 51,99	25 Mn 54,94	26 Fe 55,85	27 Co 58,93	28 Ni 58,71	29 Cu 63,55	30 Zn 65,38	31 Ga 69,72	32 Ge 72,64	33 As 74,92	34 Se 78,96	35 Br 79,90	36 Kr 83,80
37 Rb 85,47	38 Sr 87,62	39 K 39,10	40 Ca 40,08	41 Nb 92,91	42 Mo 95,94	43 Tc 98,91	44 Ru 101,07	45 Rh 102,91	46 Pd 106,42	47 Ag 107,87	48 Cd 112,41	49 In 114,82	50 Sn 118,71	51 Sb 121,76	52 Te 127,60	53 I 126,91	54 Xe 131,29
55 Cs 132,91	56 Ba 137,33	57 La 138,91	58 Ce 140,12	59 Pr 140,91	60 Nd 144,24	61 Pm	62 Sm 150,36	63 Eu 151,96	64 Gd 157,25	65 Tb 158,93	66 Dy 162,50	67 Ho 164,93	68 Er 167,26	69 Tm 168,93	70 Yb 173,05	71 Lu 174,97	72 Hf 178,49
87 Fr 223,02	88 Ra 226,03	89 Ac	90 Ce 140,12	91 Pr 140,91	92 Nd 144,24	93 Pm	94 Sm 150,36	95 Eu 151,96	96 Gd 157,25	97 Tb 158,93	98 Dy 162,50	99 Ho 164,93	100 Er 167,26	101 Tm 168,93	102 Yb 173,05	103 Lu 174,97	104 Rf 180,94

Approximate relative atomic mass
Benaderde relatiewe atoommassa



KEY / SLEUTEL
Atomic number
Atoomgetal

Electronegativity
Elektronegatiwiteit

Symbol
Simbool

58 Ce 140,12	59 Pr 140,91	60 Nd 144,24	61 Pm	62 Sm 150,36	63 Eu 151,96	64 Gd 157,25	65 Tb 158,93	66 Dy 162,50	67 Ho 164,93	68 Er 167,26	69 Tm 168,93	70 Yb 173,05	71 Lu 174,97
90 Th 232,04	91 Pa	92 U 238,03	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr