higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

CHEMICAL TECHNOLOGY N6

(15040106)

6 December 2023 (X-paper)
09:00–12:00

REQUIREMENTS: Steam table booklet required.

This question paper consists of 6 pages, a steam table and a formula sheet.

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DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
CHEMICAL TECHNOLOGY N6
TIME: 3 HOURS
MARKS: 200

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. Start each section on a new page.
5. Use only a black or blue pen.
6. Write neatly and legibly.

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QUESTION 1: DRYING

1.1 Name TWO drying processes. (2)

1.2 Name TWO coefficients that affect the drying rate of materials. (2)

1.3 List SIX types of dryers used for solids and paste. (6)

1.4 Study the diagram in FIGURE 1 and answer questions that follow:

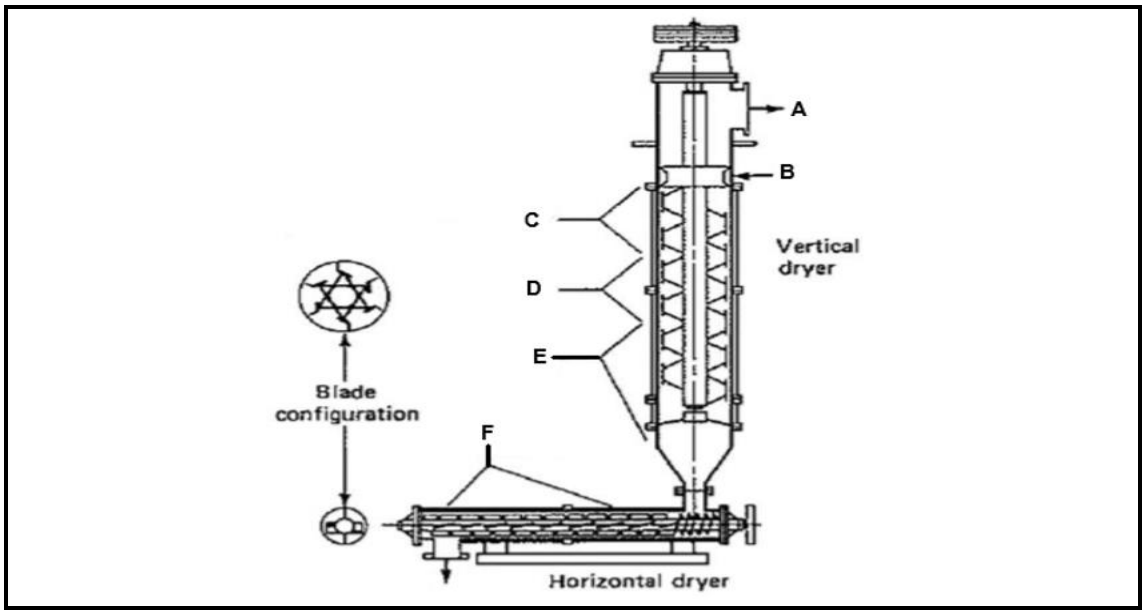


FIGURE 1: TYPICAL DRYER FOR LIQUID OR SLURRY MATERIAL

1.4.1 What is the dryer shown in FIGURE 1 called? (1)

1.4.2 Name the parts labelled A to F by writing the answer next to the letter (A–F)in the ANSWER BOOK. (6)

1.4.3 Give a brief description of the operation of the dryer in FIGURE 1. (10)

1.4.4 Explain the general guidelines that one would apply in selecting a dryer. (6)

1.5 A flash dryer is one of the dryers that evaporates solutions and slurries to dryness entirely by thermal means.

Describe the operation of a flash dryer. (10)

1.6 Give the advantages of the use of EACH of the following dryers:

1.6.1 Thin-film dryer (3)

1.6.2 Screen-conveyor dryer (4)

[50]

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QUESTION 2: CRYSTALLISATION

2.1 Spurious nucleation is one of the methods to be avoided during the formation of crystals.

2.1.1 Differentiate between *initial breeding* and *veiled growth.* (11)

2.1.2 Explain how initial breeding can be prevented. (3)

2.1.3 Name TWO methods used to avoid all forms of spurious nucleation. (2)

2.2 Describe crystallisation under the following headings:

2.2.1 Rate of nucleation (4)

2.2.2 Ostwald ripening (5)

2.3 Write brief notes on equilibrium and yields in the crystallisation processes. (10)

[35]

QUESTION 3: HEAT TRANSFER

3.1 State Fourier's law of heat transfer by conduction. (6)

3.2 Write brief notes on each of the following:

3.2.1 Absorptivity (2)

3.2.2 Emissivity (5)

3.2.3 Black body (2)

3.3 Name FIVE uses of heat exchangers in the industry. (5)

3.4 Briefly explain the following:

3.4.1 Overall coefficient of heat (5)

3.4.2 Critical temperature difference (6)

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3.5 A steam pipe has an inside diameter of 45,5 mm, a wall thickness of 4,2 mm and K = 55 $W,m^{-1}.K^{-1}$. The film coefficient inside the pipe is 2 960 $W,m^{-2}K^{-1}$. Steam with a film coefficient of 12 340 $W.M^{-2}K^{-1}$ condenses on the outside of the pipe. The total temperature is 86 °C at the inlet and 33 °C at the outlet.

Calculate how much heat is taken up by the water if the pipe is 3,5 m long assuming that the pipe is clean.

Given: $$\frac{1}{UA} = \frac{1}{h\,A'f} + \frac{1}{A''f} + \frac{X_w}{KA_w}$$

$$\Delta t_{\text{log mean}} = \frac{\Delta t_2 - \Delta t_1}{\ln \frac{\Delta t_2}{\Delta t_1}}$$

(19)
[50]

QUESTION 4: EVAPORATION

4.1 Briefly explain the difference between *evaporation*, *distillation* and *crystallisation*. (6)

4.2 Evaporators are often described according to the flow of the solution through the heat exchanger.

4.2.1 Draw a labelled diagram of a long-tube evaporator with upward flow. (7)

4.2.2 Discuss the operation of a long-tube evaporator with upward flow. (10)
[23]

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QUESTION 5: HUMIDIFICATION AND DE-HUMIDIFICATION

5.1 Briefly explain the operation of a natural-draught cooling tower. (10)

5.2 Study the drawing of a typical cooling tower in FIGURE 2 below and answer the questions that follow:

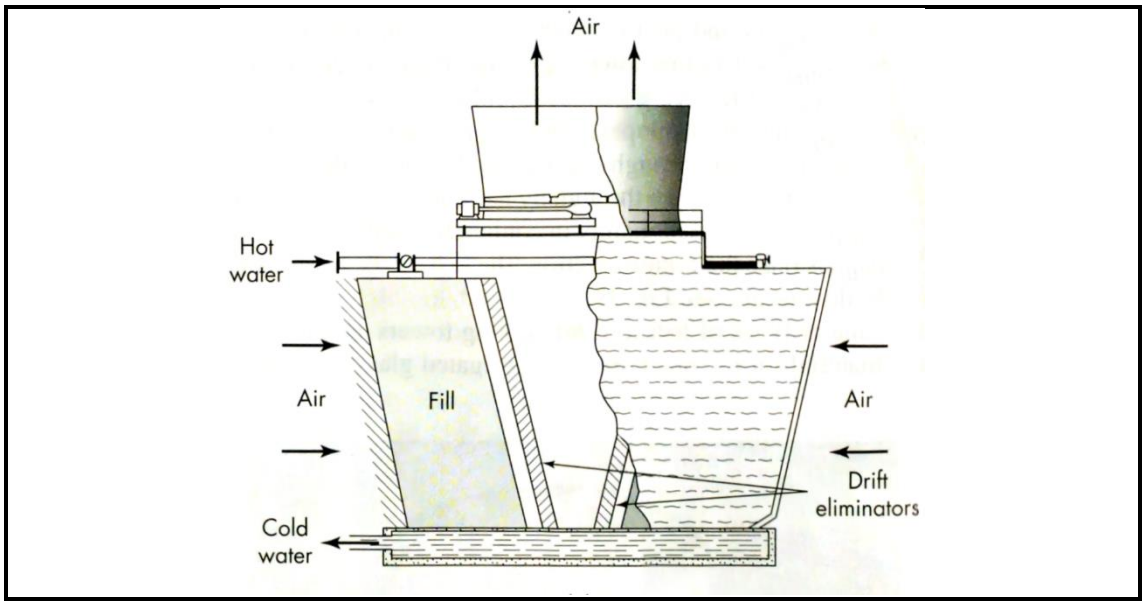


FIGURE 2: TYPICAL COOLING TOWER

5.2.1 What is the cooling tower shown in FIGURE 2 called? (2)

5.2.2 Write a brief description about the operation of the cooling tower in FIGURE 2. (12)

5.3 The partial pressure of water vapour at 60 mmHg in a mixture of air and water vapour at 40 °C is 760 mmHg.

How many kilojoules of heat energy must be added to 15 kg of the mixture to raise the temperature to 45 °C? (18)
[42]

TOTAL: 200

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(15040106)

STEAM TABLE

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
1,0	7,0	129,20	29	2 485	2 514	0,106	8,977
1,5	13,0	87,98	55	2 471	2 526	0,196	8,829
2,0	17,5	67,01	74	2 460	2 534	0,261	8,725
2,5	21,1	54,26	89	2 452	2 541	0,312	8,644
3,0	24,1	45,67	101	2 445	2 546	0,354	8,579
3,5	26,7	39,48	112	2 439	2 551	0,391	8,523
4,0	29,0	34,80	121	2 433	2 554	0,423	8,476
4,5	31,0	31,14	130	2 428	2 558	0,451	8,434
5,0	32,9	28,19	138	2 424	2 562	0,476	8,396
5,5	34,6	25,77	145	2 420	2 565	0,500	8,362
6,0	36,2	23,74	152	2 416	2 568	0,521	8,331
6,5	37,7	22,02	158	2 413	2 571	0,541	8,303
7,0	39,0	20,53	163	2 410	2 573	0,559	8,277
7,5	40,3	19,24	169	2 406	2 575	0,576	8,252
8,0	41,6	18,10	174	2 403	2 577	0,593	8,230
8,5	42,7	17,10	179	2 401	2 580	0,608	8,208
9,0	43,8	16,20	183	2 398	2 581	0,622	8,188
9,5	44,8	15,40	188	2 395	2 583	0,636	8,169
10	45,8	14,67	192	2 393	2 585	0,649	8,151
11	47,7	13,42	200	2 388	2 588	0,674	8,118
12	49,5	12,36	207	2 384	2 591	0,696	8,087
13	51,1	11,47	214	2 380	2 594	0,717	8,059
14	52,6	10,69	220	2 377	2 597	0,737	8,033
15	54,0	10,02	226	2 373	2 599	0,755	8,009
16	55,3	9,433	232	2 370	2 602	0,772	7,987
17	56,6	8,911	237	2 367	2 604	0,788	7,966
18	57,8	8,445	242	2 364	2 606	0,804	7,946
19	59,0	8,027	247	2 361	2 608	0,818	7,927
20	60,1	7,650	252	2 358	2 610	0,832	7,909
21	61,1	7,307	256	2 356	2 612	0,845	7,893
22	62,2	6,995	260	2 353	2 613	0,858	7,876
23	63,1	6,709	264	2 351	2 615	0,870	7,861
24	64,1	6,447	268	2 349	2 617	0,882	7,846
25	65,0	6,204	272	2 346	2 618	0,893	7,832
26	65,9	5,980	276	2 344	2 620	0,904	7,819
27	66,7	5,772	279	2 342	2 621	0,915	7,806
28	67,6	5,579	283	2 340	2 623	0,925	7,793
29	68,3	5,398	286	2 338	2 624	0,935	7,781
30	69,1	5,229	289	2 336	2 625	0,944	7,770
32	70,6	4,922	296	2 332	2 628	0,962	7,747
34	72,0	4,650	302	2 329	2 631	0,980	7,727
36	73,4	4,408	307	2 326	2 633	0,996	7,707
38	74,7	4,190	313	2 322	2 635	1,011	7,688
40	75,9	3,993	318	2 319	2 637	1,026	7,671
45	78,7	3,576	330	2 312	2 642	1,060	7,631
50	81,4	3,240	341	2 305	2 646	1,091	7,595
55	83,7	2,964	351	2 299	2 650	1,119	7,562
60	86,0	2,732	360	2 294	2 654	1,145	7,533
65	88,0	2,535	369	2 288	2 657	1,170	7,506
70	90,0	2,365	377	2 283	2 660	1,192	7,480

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
75	91,8	2,217	385	2 279	2 664	1,213	7,457
80	93,5	2,087	392	2 274	2 666	1,233	7,435
85	95,2	1,972	399	2 270	2 669	1,252	7,415
90	96,7	1,869	405	2 266	2 671	1,270	7,395
95	98,2	1,777	412	2 262	2 674	1,287	7,377
100	99,6	1,694	418	2 258	2 676	1,303	7,360
110	102,3	1,549	429	2 251	2 680	1,333	7,328
120	104,8	1,428	439	2 244	2 683	1,361	7,300
130	107,1	1,325	449	2 238	2 687	1,387	7,272
140	109,3	1,236	458	2 232	2 690	1,411	7,247
150	111,4	1,159	467	2 226	2 693	1,434	7,223
160	113,3	1,091	475	2 221	2 696	1,455	7,202
170	115,2	1,031	483	2 216	2 699	1,475	7,181
180	116,9	0,977 2	491	2 211	2 702	1,494	7,162
190	118,6	0,929 0	498	2 206	2 704	1,513	7,144
200	120,2	0,885 4	505	2 202	2 707	1,530	7,127
210	121,8	0,845 9	511	2 197	2 708	1,547	7,111
220	123,3	0,809 8	518	2 193	2 711	1,563	7,095
230	124,7	0,776 8	524	2 189	2 713	1,578	7,080
240	126,1	0,746 5	530	2 185	2 715	1,593	7,066
250	127,4	0,718 4	535	2 181	2 716	1,607	7,052
260	128,7	0,692 5	541	2 177	2 718	1,621	7,039
270	130,0	0,668 4	546	2 174	2 720	1,634	7,026
280	131,2	0,646 0	551	2 170	2 721	1,647	7,014
290	132,4	0,625 1	557	2 167	2 724	1,660	7,002
300	133,5	0,605 6	561	2 163	2 724	1,672	6,991
310	134,7	0,587 2	566	2 160	2 726	1,683	6,980
320	135,8	0,570 0	571	2 157	2 728	1,695	6,969
330	136,8	0,553 8	576	2 154	2 730	1,706	6,959
340	137,9	0,538 5	580	2 150	2 730	1,717	6,949
350	138,9	0,524 0	584	2 147	2 731	1,727	6,939
360	139,9	0,510 3	589	2 144	2 733	1,738	6,930
370	140,8	0,497 4	593	2 141	2 734	1,748	6,921
380	141,8	0,485 1	597	2 139	2 736	1,757	6,912
390	142,7	0,473 4	601	2 136	2 737	1,767	6,903
400	143,6	0,462 2	605	2 133	2 738	1,776	6,894
410	144,5	0,451 6	609	2 130	2 739	1,786	6,886
420	145,4	0,441 5	612	2 128	2 740	1,795	6,878
430	146,3	0,431 8	616	2 125	2 741	1,803	6,870
440	147,1	0,422 6	620	2 122	2 742	1,812	6,862
450	147,9	0,413 8	624	2 120	2 744	1,820	6,855
460	148,7	0,405 3	627	2 117	2 744	1,829	6,847
470	149,5	0,397 2	630	2 115	2 745	1,837	6,840
460	150,3	0,389 4	634	2 112	2 746	1,845	6,833
490	151,1	0,381 9	637	2 110	2 747	1,853	6,826
500	151,8	0,374 7	640	2 107	2 747	1,860	6,819
520	153,3	0,361 1	647	2 103	2 750	1,875	6,806
540	154,8	0,348 5	653	2 098	2 751	1,890	6,793
560	156,2	0,336 7	659	2 094	2 753	1,904	6,781
580	157,5	0,325 7	665	2 089	2 754	1,918	6,769

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FORMULA SHEET

$$Q = UA\Delta t$$

$$qs = mCp\Delta t$$

$$Q = q_S + q_V$$

$$qv = m^1 h_{fg}$$

$$Q(TOTAL\ ) = \left(K\ A\ \Delta\frac{t}{x}\right) + (\ K\ A\ \Delta\frac{t}{x})^2 + (\ K\ A\ \Delta\frac{t}{x})^3$$

$$\frac{1}{UA} = \frac{1}{h^1 A^1 f} + \frac{1}{h^{11} A^{11} f} + \frac{x_w}{K.A_w}$$

$$\Delta t_{lm} = \frac{\Delta t_2\ -\ \Delta t_1}{ln\frac{\Delta t_2}{\Delta t_1}}$$

$$H_a = \frac{18Pa}{29(P - pa)}$$

$$H_S = \frac{19Ps}{29(P - ps)}$$

$$H_P = H_R\left(\frac{P - ps}{P - pa}\right)$$

$$H_R = \frac{Pa}{Ps} \bullet 100$$

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