higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

CHEMICAL TECHNOLOGY N6

(15040106)

29 November 2022 (X-paper)
09:00–12:00

Drawing instruments and nonprogrammable calculators may be used.

This question paper consists of 7 pages, 1 steam table and 1 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

The following paragraphs are about the operation of a screw conveyor dryer. Complete the paragraphs by writing only the missing word or words next to the question number (1.1–1.10) in the ANSWER BOOK.

A screw conveyor is a continuous (1.1) … dryer, consisting essentially of a horizontal (1.2) … enclosed in a cylindrical (1.3) … . Solids fed in at one end are conveyed slowly through the (1.4) … and discharged from the other end. The (1.5) … is withdrawn through the pipes set in the roof of the shell.

Screw conveyor dryers handle solids that are too (1.6) … for rotary dryers. They are (1.7) … and permit recovery of solvent vapours with little or no dilution by air. When provided with appropriate feeders, they can be operated under (1.8) … . Thus they are adaptable to the continuous removal and recovery of (1.9) … from solvent-wet solids, such as spent meal from leaching operations. For that reason they are sometimes known as (1.10) … .

(10 × 1) **[10]**

QUESTION 2

Choose an item from COLUMN B that matches a description in COLUMN A. Write only the letter (A–J) next to the question number (2.1–2.5) in the ANSWER BOOK.

COLUMN A		COLUMN B	
2.1	It is characterised by atoms, molecules or ions that are arranged in orderly three-dimensional arrays	A	invariant
		B	primary nucleation
2.2	A growing crystal that maintains its geometric similarity during growth under ideal conditions	C	magma
		D	rate of nucleation
2.3	The two-phase mixture of the mother liquor and crystals of all sizes, which occupies the crystalliser and is withdrawn as the product	E	space lattice
		F	frothing
2.4	The number of the new particles formed per unit time per unit volume of the magma or solid-free mother liquor	G	entrainment
		H	crystallography
2.5	The birth of very small bodies of a new phase within a supersaturated homogenous existing phase	I	nucleation
		J	supersaturation

(5 × 2) **[10]**

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QUESTION 3

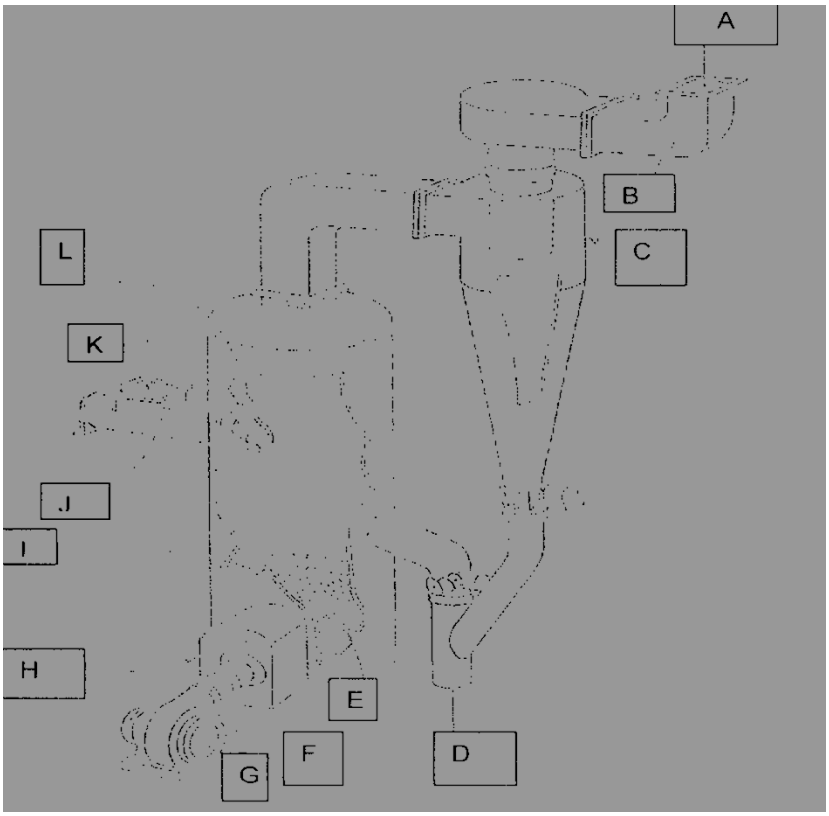
3.1 Name THREE types of material that can be dried in each of the following dryers:

3.1.1 Rotary dryer (3)

3.1.2 Screen conveyor dryer (3)

3.2 Name the TWO sections in which a thin-film dryer is built. (2)

3.3 The following diagram is a fluid-bed dryer. Label the diagram by writing only the answer next to the letter (A–L) in the ANSWER BOOK.



(12 × 1) (12)

3.4 Which type of dryer will you use to dry each of the following?

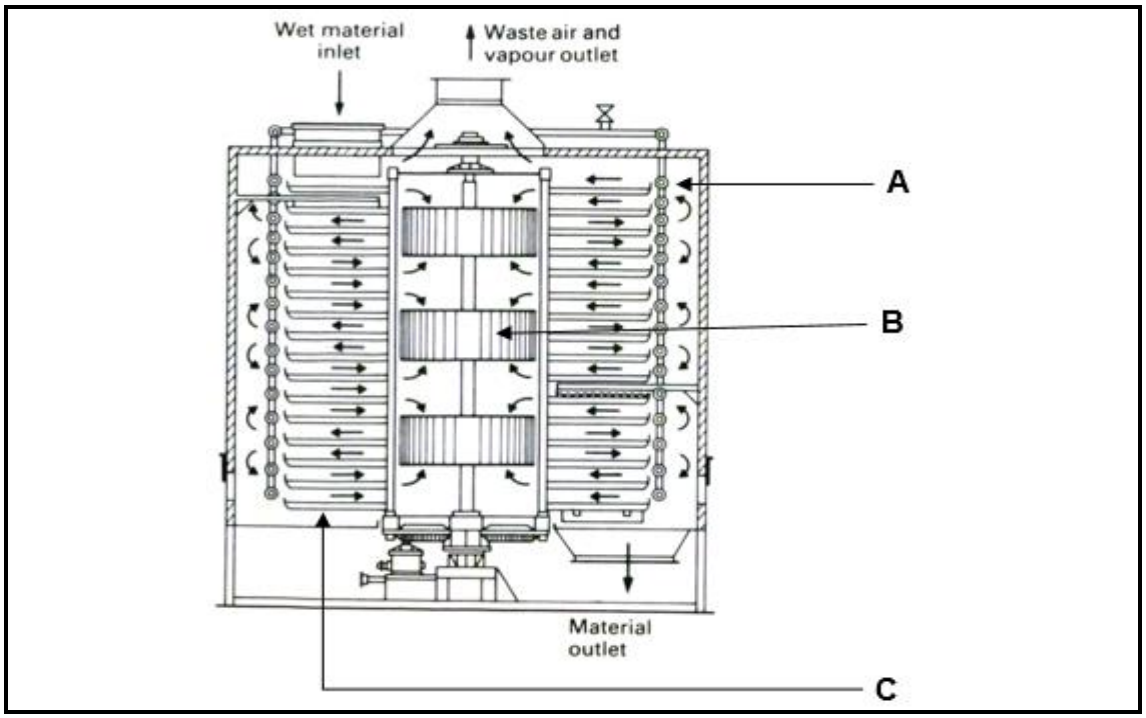
3.4.1 Concentration solution of highly soluble materials

3.4.2 Salts, sugar and all kinds of granular and crystalline material

3.4.3 Heat-sensitive materials

(3 × 2) (6)

3.5



3.5.1 Which dryer is shown in the diagram above? (1)

3.5.2 Label the parts of the dryer indicated by the letters A, B and C. (3)

3.5.3 Describe the operation of the dryer represented in the diagram above. (10)
[40]

QUESTION 4: CRYSTALLISATION

4.1 During the purification of the product, crystals are still contaminated with some of the magma from the mother liquor.

4.1.1 Describe *mother liquor*. (2)

4.1.2 Name THREE processes that are used to remove magma. (3)

4.2 List FOUR stages that are involved in the evolution of a crystal. (4)

4.3 Which TWO processes are used to regenerate supersaturation by adding a third component? (2)

4.4 Define the following terms:

4.4.1 The rate of nucleation (3)

4.4.2 Needle breeding (6)

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

4.5.1 Differentiate between *initial breeding* and *veiled growth.* (10)

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

4.5.3 Name TWO methods that are used to avoid all forms of spurious nucleation. (2)

[35]

QUESTION 5: HEAT TRANSFER

5.1 Define the following laws:

5.1.1 Stefan-Boltzmann law (3)

5.1.2 Fourier's law (4)

5.2 When heat flows through a solid by conduction, there is a certain resistance to flow determined by the thermal conductivity, cross-sectional area and thickness of the particular substance.

5.2.1 Discuss the concept of *thermal resistance in series.* (6)

5.2.2 Draw a labelled diagram showing the concept of thermal resistance in parallel. (5)

5.3 Name THREE factors that determine the resistance of heat to flow through a solid. (3)

5.4 Write brief, explanatory notes on the concept of resistance to flow of heat. (6)

[27]

QUESTION 6: EVAPORATION

6.1 Define the following terms:

6.1.1 Temperature difference driving force

6.1.2 Concept of the film

6.1.3 Boiling point elevation

6.1.4 Entrainment

(4 × 2) (8)

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6.2 An agitated film evaporator is a modified falling-film evaporator with a single-jacketed tube containing an agitator.

6.2.1 Give FOUR advantages of using an agitated-film evaporator. (4)

6.2.2 Give THREE disadvantages of an agitated-film evaporator. (3)

6.2.3 Give THREE examples of materials that can be dried using an agitated-film evaporator. (3)

6.3 Draw a labelled diagram of a long-tube vertical (climbing-film) evaporator. (8)

6.4 Write short explanatory notes on the operation of a climbing-film evaporator. (12)
[38]

QUESTION 7: HUMIDIFICATION AND DE-HUMIDIFICATION

7.1 Usually water is cooled by exposing its surface to air.

Name TWO forms of energy transfer involved when water is cooled. (2)

7.2 Describe the process that takes place in the humidifier. (9)

7.3 Write brief, clarifying notes on the relationship between wet-bulb temperature and adiabatic saturation temperature. (15)

7.4 The partial pressure of water vapour at 93 mmHg in a mixture of air and water vapour at 50 °C has a pressure of 760 mmHg.

How many kilojoules of heat energy must be added to 8 kg of the mixture to raise the temperature to 60 °C?

$C_s = 1 + 1{,}88H_a$; mass of air = total mass ÷ $(1 + H_a)$ (14)
[40]

TOTAL: 200

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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
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
480	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

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

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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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