higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

CHEMICAL TECHNOLOGY N6

(15040106)

12 August 2021 (X-paper)
09:00–12:00

Drawing instruments and nonprogrammable calculators may be used.

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

282Q1G2112

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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. Only use a black or blue pen.
6. Write neatly and legibly.

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SECTION A

QUESTION 1

1.1 Various options are given as possible answers to the following questions. Choose the correct answer and write only the letter (A–E) next to the question number (1.1.1–1.1.5) in the ANSWER BOOK.

1.1.1 Which one of the following dryers has baffles that distribute air uniformly and in which some moist air is continuously vented through an exhaust duct?

A Drum dryer
B Rotary dryer
C Flash dryer
D Spray dryer
E Tray dryer

1.1.2 The formation of solid particles in vapour/snow:

A Evaporation
B Drying
C Economy
D Crystallisation
E Capacity

1.1.3 The difference between the steam temperature and the apparent saturation temperature of the vapour leaving the evaporator mixture as determined from the pressure of the vapour:

A Standard temperature difference
B Temperature difference driving force
C Apparent temperature difference
D Dühring's rule
E Boiling point elevation

1.1.4 The nucleation that occurs at low supersaturation where the growth rate of the crystals is optimum for good quality:

A Primary nucleation
B Secondary nucleation
C Contact nucleation
D Homogeneous nucleation
E Heterogeneous nucleation

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1.1.5 The volume occupied by a unit mass of dry air plus any moisture the air may contain:

A Dew point volume
B Humid volume
C Saturation volume
D Titration volume
E Calibration volume

(5 × 2) (10)

1.2 The following question is based on the five advantages of an agitated-film evaporator.

Complete the following sentences by filling in the missing word or words. Write only the word or words next to the question number (1.2.1–1.2.10) in the ANSWER BOOK.

This evaporator has the ability to give (1.2.1) … of heat transfer with (1.2.2) … The overall coefficient (1.2.3) … as viscosity (1.2.4) … For (1.2.5) … viscous materials, the evaporator keeps the (1.2.6) … slow. With highly viscous materials, the coefficient is appreciably bigger than in (1.2.7) … and much greater than in (1.2.8) … This evaporator is particularly (1.2.9) … with (1.2.10) … sensitive products. (10)

1.3 Indicate whether the following statements are TRUE or FALSE. Choose the answer and write only 'True' or 'False' next to the question number (1.3.1–1.3.5) in the ANSWER BOOK.

1.3.1 Typical drying rate curves are based on experimental data of equilibrium moisture content at different times during the course of a drying operation.

1.3.2 Crystallisation from a solution has industrial importance because of the variety of materials that are marketed in crystalline form.

1.3.3 Water is the only volatile material available in such large quantities that it can be considered valueless.

1.3.4 Chemical processes involving the transfer of heat from one point to another are often encountered in chemical industries.

1.3.5 Air-conditioning units in homes are practical applications involving the unit operation of humidification and dehumidification.

(5 × 2) (10)

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1.4 The following diagram is of a rotary dryer. Complete the diagram by filling in the missing labels. Write only the word or words next to the question number (1.4.1–1.4.10) in the ANSWER BOOK.

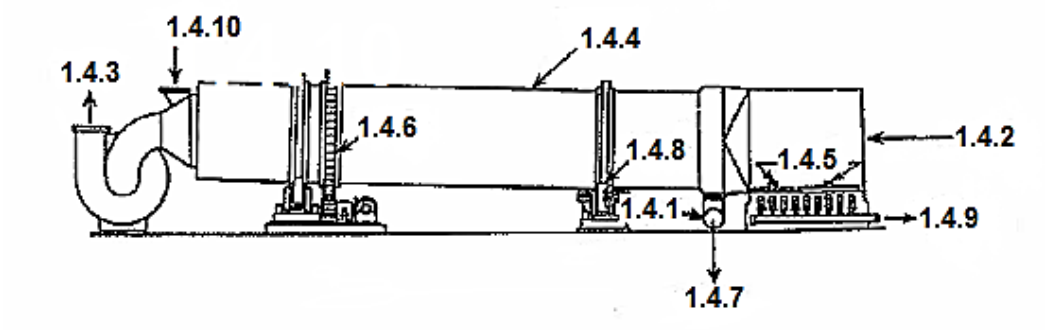


DIAGRAM (10)

1.5 Give ONE term for each of the following descriptions by writing it next to the question number (1.5.1–1.5.5) in the ANSWER BOOK.

1.5.1 The number of kilograms of water per kilogram of dry solid when the drying limit has been attained by the use of air at any given temperature and humidity

1.5.2 The formation of solid particles within a homogeneous phase

1.5.3 The process whereby fluid changes from the liquid state to the vapour state

1.5.4 The number of kilograms vaporised per kilogram of steam fed to a unit

1.5.5 The line relating air temperature to humidity at different values of percentage humidity

(5 × 2) (10)
[50]

TOTAL SECTION A: 50

SECTION B

QUESTION 2

2.1 Write brief notes on each of the following:

2.1.1 Principle of drying (10)

2.1.2 Initial breeding (5)

2.1.3 Conduction (5)

2.2 Differentiate between *drying* and *freeze drying.* (5)

2.3 A 1m long steel pipe with an inside diameter of 120 mm and a wall thickness of 80 cm carries steam at 200 °C and is isolated by 50 mm asbestos. The inside temperature of the asbestos is 100 °C and the outside temperature is 30 °C.

Given: K_{steel} = 60 W/m^{2}K and $K_{asbestos}$ = 0,07 W/m^{2}K

HINT: Use the arithmetic mean values.

Determine the following:

2.3.1 The area of the steel pipe (2)

2.3.2 The area of the pipe per asbestos (4)

2.3.3 The logarithmic mean area (3)

2.3.4 The heat lost by the steel pipe per metre pipe (4)

2.3.5 The inside area of the asbestos (2)

2.3.6 The outside area of the pipe (2)

2.3.7 The inside temperature (8)

[50]

QUESTION 3

3.1 Name THREE types of long-tube vertical evaporators. (3)

3.2 Vaporisation is the separation of water from a mixture and this separation requires energy that is supplied in the form of heat.

Name TWO sources of heat for vaporisation to occur. (2 × 2) (4)

3.3 Name SIX advantages of a spray dryer. (6)

3.4 Draw a labelled diagram of a forced-circulation evaporator and discuss its advantages in detail. (10 + 3) (13)

3.5 Define the following terms:

3.5.1 Dühring's rule and plot (5)

3.5.2 Absorptivity (3)

3.5.3 Stefan Boltzmann's law (4)

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3.6 A water solution contains 72% (m/m) of glucose. In an evaporating operation where the mixture is at its boiling point, the temperature of the solution at the surface is 369,7 K.

Use Roault's law to calculate the boiling point rise of the glucose solution if the molar mass of glucose is 346 g/mol and the molar mass of water is 18 g/mol. (12)
[50]

QUESTION 4

4.1 Write brief notes on each of the following:

4.1.1 The essential parts of the long-tube evaporator and their functions (7)

4.1.2 The concept of film (6)

4.1.3 Percentage relative humidity (10)

4.1.4 Dry bulb temperature (4)

4.1.5 The start-up operation of a heat exchanger (6)

4.1.6 Growth-related spurious nucleation (5)

4.2 Name THREE uses of logarithmic mean temperature difference. (3)

4.3 Write brief notes on equilibrium moisture content. (9)
[50]

TOTAL SECTION B: 150
GRAND TOTAL: 200

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CHEMICAL TECHNOLOGY N6

FORMULA SHEET

$$Q = UA\Delta t$$

$$qs = mCp\Delta t$$

$$Q = q_S + q_V$$

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

$$QTOTAL = (kA^{\Delta}\frac{t}{x}) + (kA^{\Delta}\frac{t}{x})^2 + (kA^{\Delta}\frac{t}{x})^3$$

$$\frac{1}{UA} = \frac{1}{h^1 A^1{}_f} + \frac{1}{h^{11} A^{11}{}_f} + \frac{x_w}{kA_w}$$

$$\Delta t_{\ell m} = \frac{\Delta t_2 - \Delta t_1}{In\,\frac{\Delta t_2}{\Delta t_1}}$$

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

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

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

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

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(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
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

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