higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

CHEMICAL TECHNOLOGY N6

(15040106)

16 April 2020 (X-paper)
09:00–12:00

Calculators may be used.

This question paper consists of 9 pages, 1 formula sheet and 1 steam table.

272Q1A2016

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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. 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 answer and write only the letter (A–D) next to the question number (1.1.1–1.1.10) in the ANSWER BOOK.

1.1.1 Evaporation occurs beneath the surface and added heat and mass transfer resistance are encountered:

A Water present on the surface
B Concept of the film
C Concept of the resistance to flow
D Water not present on the surface

1.1.2 A… is heated by direct contact of air or gas with solids, by hot gases passing through an external jacket on the shell, or by steam condensing in a set of longitudinal tubes mounted on the inner surface of the shell.

A screen-conveyor dryer
B tray dryer
C rotary dryer
D screw-conveyor dryer

1.1.3 ONE of the following cannot be dried by double-drum drying:

A Diluted solution
B Heat sensitive organic material
C Concentrated solutions of highly soluble materials
D Moderately heavy slurries

1.1.4 Formation of solid particles within a homogenous phase:

A Evaporation
B Drying
C Capacity
D Crystallisation

1.1.5 Correct sequence of stages in evolution of a crystal:

A Embryo → cluster → crystal → cluster
B Cluster → crystal → cluster → embryo
C Crystal → cluster → embryo → cluster
D Cluster → embryo → cluster → crystal

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1.1.6 Phenomenon of boiling point of liquid (solvent) becoming higher when another compound is added, meaning that solution has a higher boiling point than pure solvent:

A Boiling point rise due to material in solution
B Boiling point rise due to hydrostatic head
C Boiling point elevation
D Entrainment

1.1.7 Decrease in moisture content of air by operation in which water is transferred from vapour state to liquid state:

A Dehumidification
B Humidification
C Relative humidity
D Percentage humidity

1.1.8 Saturated volume of air versus temperature represented by curve of these lines:

A Air volume
B Humid heat
C Humidity
D Adiabatic humidification

1.1.9 Combining function of evaporator, crystalliser, dryer, size reduction unit and classifier:

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

1.1.10 Difference between temperature of condensing steam in steam chest and temperature of boiling solution at liquid vapour interface in evaporator body:

A Temperature difference driving force
B Apparent temperature difference
C Standard temperature difference
D Critical temperature difference

(10 × 2) (20)

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1.2 Indicate whether the following statements are TRUE or FALSE by writing only 'True' or 'False' next to the question number (1.2.1–1.2.10) in the ANSWER BOOK.

1.2.1 Salting occurs when the third component acts physically with the original solvent by a mixed solvent in which the solubility of the solvent is sharply decreased.

1.2.2 Homogenous nucleation occurs when the solid particles of foreign substances influence the nucleation process by catalysing an increase of the nucleation rate at any given super saturation or giving the infinite rate of super saturation.

1.2.3 A physical process is the transfer of heat from one point to another which is often encountered in the chemical industry.

1.2.4 In a typical drying rate curve, the falling rate period occurs when a part of the solid surface is no longer wetted by the liquid, the water area available for direct heat, and mass transfer decreases.

1.2.5 A flash dryer operates by a timer which moves a flapper valve so that for a fixed period of time dry solid returns to the mixer and for another fixed period it is removed as product.

1.2.6 Boiling point rise due to material is the phenomenon that the boiling point of a liquid (a solvent) will be higher when another compound is added, meaning that a solution has a higher boiling point than a pure solvent.

1.2.7 Conduction is the term given to the transfer of energy through space by electromagnetic waves.

1.2.8 Natural draught cooling towers consist of an empty shell, constructed either of timber or ferro-concrete, where the upper portion is empty and merely serves to increase the draught.

1.2.9 In most industrial processes heat is transferred from one point to another under steady conditions of temperature difference, length of heat flow path and cross sectional area and is called the condition of steady flow of heat.

1.2.10 Apparent temperature difference is the difference between the steam temperature and the apparent temperature of the vapour leaving the evaporating mixture.

(10 × 1) (10)

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1.3 Choose a term from COLUMN B that matches a description in COLUMN A. Write only the letter (A–K) next to the question number (1.3.1–1.3.10) in the ANSWER BOOK.

COLUMN A		COLUMN B	
1.3.1	Dryer operated under vacuum, often with direct heating	A	screen-conveyor dryer
1.3.2	Dryer 1,8 m wide and 3,6 m long giving drying time of 5 to 120 minutes	B	long-tube vertical evaporator
1.3.3	Evaporator often used as natural circulation	C	capacity
1.3.4	During course of evaporation solids are often deposited on heat transfer surfaces	D	tray dryer
1.3.5	Liquid mixture containing suspended solids tends to foul heat exchanger rapidly	E	nucleation
1.3.6	Evaporator operating at a low temperature difference between heating media and boiling liquid	F	evaporation
1.3.7	Dryers in which solids are fluidised by drying gas or air in boiled-bed unit	G	dirt deposit
1.3.8	Number of kilogram of water vaporised per hour	H	economy
1.3.9	Number of new particles formed per unit time per unit volume of solid-free mother liquor	I	scale formation
1.3.10	Operation in which fluid changes from liquid state to vapour state	J	fluid-bed dryer
		K	falling-film evaporator

(10 × 1) (10)

1.4 Complete the following sentences by writing only the missing word or words next to the question number (1.4.1–1.4.10) in the ANSWER BOOK.

1.4.1 Drying is the operation that involves the simultaneous transfer of … and heat.

1.4.2 … is used when production rates are low, hold-up times in units are long or when different types of products must be dried.

1.4.3 During initial breeding seeds are usually carried on their …

1.4.4 … is one of the essential parts of the long-tube vertical evaporator which removes entrained liquids from the vapour.

1.4.5 When feed to the evaporator is at boiling point the heat transferred through the heating surface is available for … and capacity is proportional to the rate of heat transfer.

1.4.6 … is the temperature at which a given air and water vapour mixture would be saturated.

1.4.7 One of the factors that determine the rate of heat transfer in the continuous evaporator operating under a steady state is the amount of … required to heat the feed from its entering temperature to the boiling temperature.

1.4.8 The degree of saturation expressed as 100 times the actual partial pressure of pure water vapour in the air divided by the saturation vapour pressure of the pure water at the same temperature is called …

1.4.9 A wet-bulb thermometer is kept wet by means of a cloth saturated with water and the thermometer indicates the equilibrium temperature attained in the …

1.4.10 Apparent temperature difference is the difference between the steam temperature and the … of vapour leaving the evaporating mixture as determined by the pressure of the vapour.

(10 × 1) (10)
[50]

TOTAL SECTION A: 50

SECTION B

QUESTION 2

2.1 Discuss each of the following regarding agitated film evaporators:

2.1.1 Operation principle (8)

2.1.2 Advantages (6)

2.1.3 Uses (4)

2.2 List FOUR factors influencing the performance of spray. (4)

2.3 Discuss the drying principle. (10)

2.4 Draw a labelled diagram of a rotary dryer. (18)
[50]

QUESTION 3

3.1 Write brief notes on each of the following:

3.1.1 Initial breeding (5)

3.1.2 Film (4)

3.1.3 Enthalpy balance (8)

3.2 List THREE classifications of nucleation groups. (3)

3.3 Name TREE advantages of each of the following:

3.3.1 Forced circulation evaporator

3.3.2 Flash dryer

3.3.3 Falling-fluid evaporator

(3 × 3) (9)

3.4 Indicate the transfer of heat in each of the following situations with the aid of labelled diagrams:

3.4.1 Parallel resistance

3.4.2 Series resistance

(2 × 4) (8)

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3.5 A student generates the following data while performing an experiment in the laboratory:

Water solution contains 78% (m/m) starch.
Temperature of solution is 361,4 K
Molar mass of starch solution is 342 g/mol
Molar mass of water is 18 g/mol

Use Raoult's law to determine the temperature of the starch solution. (13)
[50]

QUESTION 4

4.1 Define each of the following:

4.1.1 Equilibrium moisture content (4)

4.1.2 Duhring's rule (4)

4.1.3 Fourier's law (5)

4.1.4 Saturation volume (4)

4.1.5 Magma (3)

4.1.6 Evaporation (3)

4.1.7 Drying (2)

4.2 A laboratory is at an absolute pressure of 760 mmHg and contains 0,025 kg water vapour/kg dry air. The room temperature is 31,5 ˚C. The saturated vapour pressure of water at 31,5 ˚C is 4,63 kPa.

4.2.1 Prove that the saturated vapour pressure of water at 31,5 ˚C is 4,63 kPa. (3)

4.2.2 Calculate the percentage humidity. (8)

4.2.3 Calculate the relative percentage humidity. (8)

4.3 Name THREE essential parts for long-tube evaporators with upward flow and give ONE function of each. (6)
[50]

TOTAL SECTION B: 150
GRAND TOTAL : 200

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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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CHEMICAL TECHNOLOGY N6

STEAM TABLES

p	t_s	v_g	h_f	h_{fg}	h_g	s_f	s_g
kPa	°C	m³/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	m³/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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