higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

CHEMICAL TECHNOLOGY N6

(15040106)

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09:00–12:00

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

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DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
CHEMICAL TECHNOLOGY N6
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. Start each section on a new page.
5. Write neatly and legibly.

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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 Kilograms of water per kilogram dry solid when drying limit has been attained by using air at any given temperature and humidity:

A Equilibrium moisture content
B Free moisture content
C Dry weight basis
D Evaporation

1.1.2 Number of new particles produced in magma or mother liquor per unit time:

A Initial breeding
B Needle breeding
C Veiled growth
D Nucleation

1.1.3 Hot air passing over surface and acting as heat source is in direct contact with this water:

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

1.1.4 Which ONE does not influence performance of spray dryer?

A Size and shape of chamber
B Energy and terminal velocity of drops
C Size and terminal velocity of drops
D Flow pattern and velocity of air as well as time spent in drying chamber

1.1.5 Separation of liquid mixture by using partial vaporisation:

A Cooling tower
B Fractionation tower
C Distillation column
D Evaporation

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1.1.6 Type of dryer in which small droplets falls through hot gases; the large area that transfers heat permits rapid drying:

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

1.1.7 Heat transfer where there is no actual movement or flow of material and molecules vibrate in just one spot but energy is transmitted:

A Conduction
B Radiation
C Convection
D Steam stripper

1.1.8 If air and water are kept in contact, water will continue to vaporise until vapour pressure of water equals equilibrium vapour pressure of water at temperature of mixture:

A Saturation volume
B Saturated air
C Raoult's law
D During's rule

1.1.9 Nucleation that occurs at low super-saturations where growth rate of crystals is at optimum for quality:

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

1.1.10 Third component acting physically by forming, with original solvent, a mixed solvent in which solubility of solvent is sharply reduced:

A Salting
B Precipitation
C Evaporation
D Distillation

(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 In a typical drying rate curve, the falling rate period is represented by a straight, horizontal line showing no change in the rate of the water removal as the moisture content of the solid is reduced.

1.2.2 A screw-conveyor dryer is a continuous direct-heat dryer consisting essentially of a horizontal screw conveyor enclosed in the cylindrical jacketed shell.

1.2.3 Dry-wet basis, the amount of added water that can be removed, can be determined by obtaining the difference between the water contents at any two times.

1.2.4 When evaporator bodies are connected in series so that the vapour from one body acts as a heat source for the next evaporator body it is known as a multiple-effect evaporator.

1.2.5 Boiling-point rise due to hydrostatic head is the actual temperature of the mixture minus the temperature of the pure solvent if it exerts the same vapour pressure of the mixture.

1.2.6 When a fluid is flowing past a stationary surface a thin film of the fluid postulated as existing between the flowing fluid and the stationary surface is regarded as a concept of the film.

1.2.7 Radiation happens when radiant energy strikes a surface and part of the energy is absorbed, part is reflected, and some may pass through the receiver unaffected if the body is not completely opaque.

1.28 Most heat exchangers are equipped with floating heads or expansion joints to handle the volume changes of the metallic parts within temperature variations.

1.2.9 Mechanical draught cooling towers may employ a forced draught with the fan at the bottom or an induced draught with the fan driving the moist air out at the top.

1.2.10 The concept of heat resistance occurs when heat flows through a solid substance by conduction and resistance to the flow is determined by the thermal conductivity, cross sectional area and the thickness of the surface.

(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 consisting of a slightly inclined rotating cylinder, fitted with a series of peripheral flights arranged to lift and distribute the material	A	precipitation
1.3.2	A new solute may be chemically created by adding a third component that will react with the original solute and form an insoluble substance	B	rotary dryer
1.3.3	Number of kilograms vaporised per kilogram team fed to unit	C	comminution
1.3.4	Dryer consisting of stack of rotating circular trays	D	convection
1.3.5	Action of reducing a material, an ore, to minute particles of fragments	E	salting
1.3.6	Removal of water from material containing small amount of water	F	tray dryer
1.3.7	Dryer operated under vacuum, often with direct heating	G	economy
1.3.8	The third may act physically by forming' with the original solvent, a mixed solvent in which the solubility of the solvent is sharply reduced	H	tower dryer
1.3.9	Dryer consisting of series of circular trays mounted one above the other on central rotating shaft	I	turbo dryer
1.3.10	Physical movement of vibrating particles transferring heat from one point to another in a substance by agitation	J	capacity
		K	drying

(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 … is used to allow liquid to be concentrated in the long tube vertical evaporator.

1.4.2 Fragile crystals of heat-sensitive organic materials are dried in un-agitated equipment by …

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1.4.3 One of the factors that determine the rate of heat transfer in the continuous evaporator operating under steady state is the amount of … required to vaporise the water.

1.4.4 When the feed has a temperature above the boiling point in the evaporator space, some of the feed evaporates spontaneously by … with the vapour space pressure.

1.4.5 Temperature difference driving force is the temperature between the temperature of the … in the steam chest and the temperature of the boiling solution at the liquid-vapour interface in the evaporator body.

1.4.6 During initial breeding the small crystals soon … and grow in the super-saturated solution.

1.4.7 … is the temperature difference when the individual heat transfer coefficient starts to decrease markedly through formation of an insulating and vapour film.

1.4.8 … is the decrease in moisture content of air by an operation whereby water is transferred from the vapour state to the liquid state.

1.4.9 During drying, the rate of water removal is determined by the rate of …

1.4.10 … is the part of a vacuum evaporating system in which the liquid to be concentrated rises through tubes surrounded by steam and descends through the central well.

(10 × 1) (10)
[50]

TOTAL SECTION A: 50

SECTION B

QUESTION 2

2.1 Explain each of the following regarding a spray drier:

2.1.1 Operation (10)

2.1.2 Advantages (6)

2.1.3 Uses (3)

2.2 Name FIVE factors to consider when selecting a dryer. (5)

2.3 Draw a labelled diagram of a thin-film dryer. (10)

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2.4 Name TWO types of steam-heated tubular evaporators. (2)

2.5 The partial pressure of water vapour is 35 mmHg while the temperature of air and water vapour is 46 °C. The atmospheric pressure is 101,3 kPa.

Calculate the amount of heat energy to be added to 0,05 kg of the mixture to raise the temperature to 52 °C.

Given:

$$H_a = \frac{18\,P_a}{29\,(P - P_a)}$$

(14)
[50]

QUESTION 3

3.1 Write brief notes on each of the following:

3.1.1 Needle breeding (5)

3.1.2 Purity of the product (8)

3.1.3 Ostwald ripening (6)

3.2 Differentiate between *equilibrium moisture content* and *critical free moisture content.* (6)

3.3 Name TWO types of each of the following:

3.3.1 Secondary nucleation

3.3.2 Long-tube vertical evaporators

3.3.3 Cooling towers

(3 × 2) (6)

3.4 Define each of the following:

3.4.1 Percentage humidity (4)

3.4.2 Raoult's law (5)

3.4.3 Dry weight basis (3)

3.5 Give TWO principles of crystallisation. (2)

3.6 Explain the operation of the fluid-bed drier. (5)
[50]

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QUESTION 4

4.1 Write brief notes on each of the following:

4.1.1 Natural convection of gases (5)

4.1.2 Adiabatic evaporation (8)

4.1.3 Boiling point rise due to hydrostatic head (10)

4.2 Give TWO uses of each of the following:

4.2.1 Forced-circulation evaporators

4.2.2 Heat exchangers in the industry

4.2.3 Rotary dryers

(3 × 2) (6)

4.3 Define each of the following:

4.3.1 Emissivity (4)

4.3.2 Fourier's law (5)

4.3.3 Dry-bulb temperature (3)

4.4 Derive a formula for the relationship between percentage humidity and percentage relative humidity. (9)

[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

INFORMATION SHEET

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	1,328	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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