higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

CHEMICAL TECHNOLOGY N6

(15040106)

21 April 2021 (X-paper)
09:00–12:00

Nonprogrammable calculators and drawing instruments may be used.

This question paper consists of 8 pages, 1 formula sheet and 1 steam table.

274Q1A2121

Copyright reserved

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.

Copyright reserved

SECTION A

QUESTION 1

1.1 Various options are given as possible answers to the questions. Choose the answer and write the letter (A–D) next to the question number (1.1.1–1.1.10) in the ANSWER BOOK.

1.1.1 Which dryer is suitable for drying materials that can be agitated?

A Screen-conveyor dryer
B Spray dryer
C Screw-conveyor dryer
D Fluid-bed dryer

1.1.2 Which material is not used in a rotary dryer?

A Granular
B Sugar
C Synthetic detergent
D Salt

1.1.3 Based on the drying curve, the phase during which migration of moisture from the inner interstices of each particle to the outer surface becomes the limiting factor that reduces the drying rate:

A Uniform rate period
B Falling rate period
C Initial period
D Increasing rate period

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

A Primary nucleation
B Tertiary nucleation
C Secondary nucleation
D Contact nucleation

1.1.5 Which method cannot prevent initial breeding?

A Curing the seed crystals before using
B Generating bubbles in a superheated liquid
C Preliminary growth in a stagnant super saturation solution
D Contact with an under-saturated solution

Copyright reserved

1.1.6 A dryer that combines the function of an evaporator, a crystalliser, a dryer, a size-reduction unit and a classifier:

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

1.1.7 100 times the ratio of the actual humidity of air to humidity if the air was saturated at the same temperature and total pressure:

A Percentage relative humidity
B Humidification
C Percentage humidity
D Dehumidification

1.1.8 The difference between the temperature of the condensing steam in the steam chest and the temperature of the boiling liquid in the evaporator body:

A Temperature difference driving force
B Apparent temperature difference
C Critical temperature difference
D Individual film coefficient of heat transfer

1.1.9 The removal of water vapour in a pure state from a mixture containing a relatively large amount of water:

A Drying
B Capacity
C Evaporation
D Crystallisation

1.1.10 If large crystals are also present in a solution, the smaller crystals will dissolve and the larger ones will grow until the small crystals disappear:

A Initial breeding
B Needle breeding
C Veiled growth
D Ostwald ripening

(10 × 2) (20)

Copyright reserved

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

1.2.1 Growth-related spurious nucleation is characterised by abnormal needle-like and whisker-like growth from the ends of the crystals that, under these conditions, may grow slower than the sides.

1.2.2 According to Raoult's law, the total vapour pressure of an ideal solution is directly dependent on the vapour pressure of each chemical component and the mole fraction of the components present in the solution.

1.2.3 Humid heat lines are straight lines that give the relationship between humidity and humid heat.

1.2.4 Magma is the two-phase mixture of mother liquor and crystals of all sizes that occupies the crystalliser and is withdrawn as product.

1.2.5 Humid heat is the temperature at which a given air and water vapour mixture would be saturated.

1.2.6 If water is present on a surface, hot air passing over the surface and acting as a heat source will be in direct contact with the water and the resistance to heat and mass transfer will be due only to the liquid and gas films.

1.2.7 Heterogeneous nucleation occurs when the solid particles of a foreign substance influence the nucleation process by catalysing an increase of the nucleation rate at a given super saturation or by giving a finite rate at super saturation.

1.2.8 The amount of water that can be removed from a wet solid under any given conditions of air humidity and temperature is known as dry-weight basis.

1.2.9 In a spray dryer small droplets fall through the hot gases and the large heat-transfer area exposed permits a rapid drying rate.

1.2.10 Boiling point rise due to hydrostatic head is the phenomenon that occurs when the boiling point of a liquid will be higher when another compound is added, meaning that a solution has a higher boiling point than a pure solvent.

(10 × 1) (10)

Copyright reserved

1.3 Give ONE term for each of the descriptions by writing it next to the question number (1.3.1–1.3.10) in the ANSWER BOOK.

1.3.1 Number of new particles produced in magma or mother liquor per unit time.

1.3.2 Evaporator where sufficient static head ensure that there is no boiling in the tubes.

1.3.3 Carrying over of liquid droplets into the vapour space on an evaporator because the vapour velocity is high enough to overcome the tendency for the liquid to settle.

1.3.4 Kilogram vapour per kilogram steam fed to a unit.

1.3.5 Increasing the evaporation per kilogram of steam by using a series of evaporators between the steam supply and the condenser.

1.3.6 Instantaneous rate of heat transfer through a homogeneous body by conduction directly proportional to the temperature difference driving force across the body and to the cross-sectional area of the body and the rate of heat transfer is inversely proportional to the thickness of the body.

1.3.7 Body emitting radiant energy in all directions striking a receiver where part of it may be absorbed and part of it may be reflected.

1.3.8 Feed at a temperature above the boiling point in the vapour space where a portion of the feed evaporates spontaneously by adiabatic equilibration with the vapour-space pressure and the capacity is greater than that of the corresponding rate of heat transfer.

1.3.9 Body absorbing all radiant energy received on its surface and reflecting and transmitting none.

1.3.10 Continuous indirect-heat dryer consisting of a horizontal screw-conveyor enclosed in a cylindrical jacketed shell.

(10 × 1) (10)
[40]

TOTAL SECTION A: 40

QUESTION 2

2.1 Explain the operation of a flash dryer. (10)

2.2 Explain each of the terms as it relates to a falling-film evaporator:

2.2.1 Operation (6)

2.2.2 Advantages (3)

2.2.3 Uses (2)

2.3 Give THREE uses of a heat exchanger in the industry. (3)

2.4 State TWO methods to measure the performance of a steam-heated tubular evaporator. (2)

2.5 Draw and label a diagram of a spray dryer. (25)

2.6 Briefly explain dryers for solids and paste. (9)
[60]

QUESTION 3

3.1 Define each of the terms:

3.1.1 Freeze-drying (3)

3.1.2 Crystallisation (2)

3.1.3 Humidity (3)

3.1.4 Absorptivity (2)

3.1.5 Steady flow of heat (3)

3.1.6 Stefan Boltzmann's law (4)

3.2 The wall of a copper furnace is constructed of 0,12 m of induction furnace. The induction furnace has a thermal conductivity of 3,89 W/mK. The outside of the furnace is covered with a 40 mm ceramic fibre with a thermal conductivity of 0,46 W/mK. The inner surface of the furnace is 1 356 K and the outside surface temperature is 1 250 K. $Q = KA\Delta t/x$.

Calculate the heat loss through the induction furnace of 0,35 m by 1,5 m. (19)

3.3 Differentiate between economy and capacity. (2 + 2) (4)

3.4 Briefly explain boiling point rise due to material. (10)
[50]

Copyright reserved

QUESTION 4

4.1 List THREE factors that influence:

4.1.1 Economy of an evaporator system

4.1.2 Humidification and dehumidification calculations

(2 × 3) (6)

4.2 Briefly explain each:

4.2.1 Veiled growth (5)

4.2.2 Standard temperature difference (4)

4.2.3 Conduction (4)

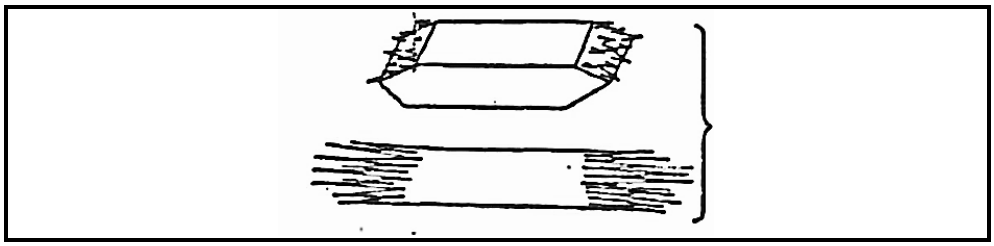
4.2.4 Natural convection of gases (6)

4.2.5 Equilibrium moisture content (4)

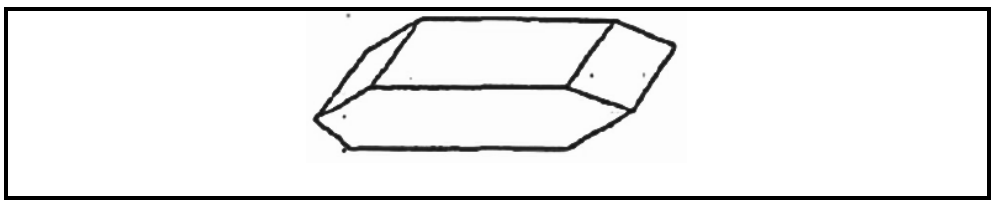
4.3 Explain the operation of a natural circulation tower. (6)

4.4 Name and give a suitable operating temperature for each of the diagrams:

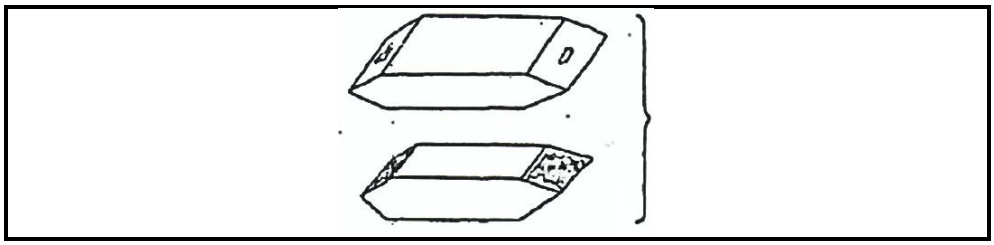
4.4.1



4.4.2



4.4.3



(3 × 2) (6)

4.5 Draw and label a diagram of a climbing-film long-tube vertical evaporator. (9)

[50]

TOTAL SECTION B: 160
GRAND TOTAL: 200

Copyright reserved

FORMULA SHEET

$$Q = UA\Delta t$$

$$qs = mCp\Delta t$$

$$Q = q_S + q_V$$

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

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

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

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

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

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

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

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

Copyright reserved

(15040106)

STEAM TABLE

p	t_s	v_g	h_f	h_{fg}	h_g	s_f	s_g	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	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	75	91,8	2,217	385	2 279	2 664	1,213	7,457
1,5	13,0	87,98	55	2 471	2 526	0,196	8,829	80	93,5	2,087	392	2 274	2 666	1,233	7,435
2,0	17,5	67,01	74	2 460	2 534	0,261	8,725	85	95,2	1,972	399	2 270	2 669	1,252	7,415
2,5	21,1	54,26	89	2 452	2 541	0,312	8,644	90	96,7	1,869	405	2 266	2 671	1,270	7,395
3,0	24,1	45,67	101	2 445	2 546	0,354	8,579	95	98,2	1,777	412	2 262	2 674	1,287	7,377
3,5	26,7	39,48	112	2 439	2 551	0,391	8,523	100	99,6	1,694	418	2 258	2 676	1,303	7,360
4,0	29,0	34,80	121	2 433	2 554	0,423	8,476	110	102,3	1,549	429	2 251	2 680	1,333	7,328
4,5	31,0	31,14	130	2 428	2 558	0,451	8,434	120	104,8	1,428	439	2 244	2 683	1,361	7,300
5,0	32,9	28,19	138	2 424	2 562	0,476	8,396	130	107,1	1,325	449	2 238	2 687	1,387	7,272
5,5	34,6	25,77	145	2 420	2 565	0,500	8,362	140	109,3	1,236	458	2 232	2 690	1,411	7,247
6,0	36,2	23,74	152	2 416	2 568	0,521	8,331	150	111,4	1,159	467	2 226	2 693	1,434	7,223
6,5	37,7	22,02	158	2 413	2 571	0,541	8,303	160	113,3	1,091	475	2 221	2 696	1,455	7,202
7,0	39,0	20,53	163	2 410	2 573	0,559	8,277	170	115,2	1,031	483	2 216	2 699	1,475	7,181
7,5	40,3	19,24	169	2 406	2 575	0,576	8,252	180	116,9	0,977 2	491	2 211	2 702	1,494	7,162
8,0	41,6	18,10	174	2 403	2 577	0,593	8,230	190	118,6	0,929 0	498	2 206	2 704	1,513	7,144
8,5	42,7	17,10	179	2 401	2 580	0,608	8,208	200	120,2	0,885 4	505	2 202	2 707	1,530	7,127
9,0	43,8	16,20	183	2 398	2 581	0,622	8,188	210	121,8	0,845 9	511	2 197	2 708	1,547	7,111
9,5	44,8	15,40	188	2 395	2 583	0,636	8,169	220	123,3	0,809 8	518	2 193	2 711	1,563	7,095
10	45,8	14,67	192	2 393	2 585	0,649	8,151	230	124,7	0,776 8	524	2 189	2 713	1,578	7,080
11	47,7	13,42	200	2 388	2 588	0,674	8,118	240	126,1	0,746 5	530	2 185	2 715	1,593	7,066
12	49,5	12,36	207	2 384	2 591	0,696	8,087	250	127,4	0,718 4	535	2 181	2 716	1,607	7,052
13	51,1	11,47	214	2 380	2 594	0,717	8,059	260	128,7	0,692 5	541	2 177	2 718	1,621	7,039
14	52,6	10,69	220	2 377	2 597	0,737	8,033	270	130,0	0,668 4	546	2 174	2 720	1,634	7,026
15	54,0	10,02	226	2 373	2 599	0,755	8,009	280	131,2	0,646 0	551	2 170	2 721	1,647	7,014
16	55,3	9,433	232	2 370	2 602	0,772	7,987	290	132,4	0,625 1	557	2 167	2 724	1,660	7,002
17	56,6	8,911	237	2 367	2 604	0,788	7,966	300	133,5	0,605 6	561	2 163	2 724	1,672	6,991
18	57,8	8,445	242	2 364	2 606	0,804	7,946	310	134,7	0,587 2	566	2 160	2 726	1,683	6,980
19	59,0	8,027	247	2 361	2 608	0,818	7,927	320	135,8	0,570 0	571	2 157	2 728	1,695	6,969
20	60,1	7,650	252	2 358	2 610	0,832	7,909	330	136,8	0,553 8	576	2 154	2 730	1,706	6,959
21	61,1	7,307	256	2 356	2 612	0,845	7,893	340	137,9	0,538 5	580	2 150	2 730	1,717	6,949
22	62,2	6,995	260	2 353	2 613	0,858	7,876	350	138,9	0,524 0	584	2 147	2 731	1,727	6,939
23	63,1	6,709	264	2 351	2 615	0,870	7,861	360	139,9	0,510 3	589	2 144	2 733	1,738	6,930
24	64,1	6,447	268	2 349	2 617	0,882	7,846	370	140,8	0,497 4	593	2 141	2 734	1,748	6,921
25	65,0	6,204	272	2 346	2 618	0,893	7,832	380	141,8	0,485 1	597	2 139	2 736	1,757	6,912
26	65,9	5,980	276	2 344	2 620	0,904	7,819	390	142,7	0,473 4	601	2 136	2 737	1,767	6,903
27	66,7	5,772	279	2 342	2 621	0,915	7,806	400	143,6	0,462 2	605	2 133	2 738	1,776	6,894
28	67,6	5,579	283	2 340	2 623	0,925	7,793	410	144,5	0,451 6	609	2 130	2 739	1,786	6,886
29	68,3	5,398	286	2 338	2 624	0,935	7,781	420	145,4	0,441 5	612	2 128	2 740	1,795	6,878
30	69,1	5,229	289	2 336	2 625	0,944	7,770	430	146,3	0,431 8	616	2 125	2 741	1,803	6,870
32	70,6	4,922	296	2 332	2 628	0,962	7,747	440	147,1	0,422 6	620	2 122	2 742	1,812	6,862
34	72,0	4,650	302	2 329	2 631	0,980	7,727	450	147,9	0,413 8	624	2 120	2 744	1,820	6,855
36	73,4	4,408	307	2 326	2 633	0,996	7,707	460	148,7	0,405 3	627	2 117	2 744	1,829	6,847
38	74,7	4,190	313	2 322	2 635	1,011	7,688	470	149,5	0,397 2	630	2 115	2 745	1,837	6,840
40	75,9	3,993	318	2 319	2 637	1,026	7,671	480	150,3	0,389 4	634	2 112	2 746	1,845	6,833
45	78,7	3,576	330	2 312	2 642	1,060	7,631	490	151,1	0,381 9	637	2 110	2 747	1,853	6,826
50	81,4	3,240	341	2 305	2 646	1,091	7,595	500	151,8	0,374 7	640	2 107	2 747	1,860	6,819
55	83,7	2,964	351	2 299	2 650	1,119	7,562	520	153,3	0,361 1	647	2 103	2 750	1,875	6,806
60	86,0	2,732	360	2 294	2 654	1,145	7,533	540	154,8	0,348 5	653	2 098	2 751	1,890	6,793
65	88,0	2,535	369	2 288	2 657	1,170	7,506	560	156,2	0,336 7	659	2 094	2 753	1,904	6,781
70	90,0	2,365	377	2 283	2 660	1,192	7,480	580	157,5	0,325 7	665	2 089	2 754	1,918	6,769

Copyright reserved