higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T340**(E)**(M27)T

NATIONAL CERTIFICATE

CHEMICAL TECHNOLOGY N6

(15040106)

27 March 2019 (X-Paper)
09:00–12:00

Calculators may be used.

This question paper consists of 6 pages, 1 formula sheet and a steam table of 2 pages.

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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. Sketches must be large, neat and fully labelled.
5. Keep subsections of questions together.
6. Start each calculation with the formula and give substituted values.
7. Each final answer must be rounded off to THREE decimal numbers.
8. Write neatly and legibly.

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QUESTION 1

1.1 Provide a suitable term of each of the following statements:

1.1.1 The removal of water from materials containing a relatively small amount of water

1.1.2 A process where a new solute may be created chemically by adding a third component that will react with the original solute and form an insoluble substance

1.1.3 A linear relationship exists between the temperatures at which two solutes exert the same vapour pressure

1.1.4 The number of the kilograms of water vaporised per hour

1.1.5 The sublimation of water vapour from ice under high vacuum at temperatures below 0 °C

(5 × 2) (10)

1.2 Write brief notes on *adiabatic evaporation*. (10)

1.3 Complete the following paragraph regarding the operation principle of a fluid-bed dryer by writing only the missing word(s) next to the question number (1.3.1–1.3.9) in the ANSWER BOOK.

Particles are fluidised by air or gas in a (1.3.1) … where mixing and heat transfer is rapid. The (1.3.2) … is admitted at the top of the dryer. The (1.3.3) … is removed near the bottom. Drying time is short, between 30 and 60 seconds. (1.3.4) … material must be dried in a relative cool suspending medium. The dry product must be mixed with (1.3.5) … to improve (1.3.6) … characteristics and reduce (1.3.7) … Such dryer may be (1.3.8) … or 1.3.9 …

(9 × 1) (9)

1.4 Name FOUR factors that influence the performance of the spray dryer. (7)

1.5 Write brief notes on the operation of the screen conveyor dryer. (10)

1.6 Name a suitable type of dryer used for each of the following:

1.6.1 Rigid or granular solids

1.6.2 Material that cannot be agitated

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1.6.3 Concentrated solution of highly soluble materials

1.6.4 Heat-sensitive materials that can be dried

(4 × 1) (4)
[50]

QUESTION 2

2.1 Write brief notes on the following:

2.1.1 Veiled growth

2.1.2 Heterogeneous nucleation

(2 × 5) (10)

2.2 Yielding from a solution, slurry or thin paste is one of the main advantages of the spray dryer.

Name FIVE types of equipment that can produce this advantage. (5)

2.3 Name FIVE properties of evaporating liquids. (5)

2.4 A water solution contains 72% (m/m) sugar at 96,5 °C. In an evaporating operation where the mixture is at its boiling point, the temperature of the solution is 96,7 °C. The molar mass of the sugar solution is 354 g/mol and the molar mass of the water is 18 g/mol.

Calculate the *equilibrium pressure* and *mole fraction* of the water. (10)

2.5 Differentiate between the *absence* and the *presence* of solid crystal contact nucleation. (2 × 2) (4)

2.6 Name TWO types of secondary nucleation. (2)

2.7 Name THREE types of nucleation. (3)

2.8 Define the following:

2.8.1 Calandria

2.8.2 Entrainment

(2 × 2) (4)

2.9 Draw and label a diagram of a forced-circulation evaporator. (7)
[50]

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QUESTION 3

3.1 Write notes on the multiple-effect evaporator. (4)

3.2 Name THREE essential parts of a long-tube evaporator with upward flow. (3)

3.3 The capacity of evaporators varies according to the temperature of the feed.

Write notes on the following headings:

3.3.1 When the feed to the evaporator is at boiling point (3)

3.3.2 When the feed is cold (3)

3.3.3 When the temperature of the feed in the evaporator space is above boiling point (4)

3.4 Discuss the operation of an agitated film evaporator. (10)

3.5 Name THREE types of cooling towers. (3)

3.6 Name TWO processes involved in the drying process. (2 × 2) (4)

3.7 Define the following:

3.7.1 Fourier's law (6)

3.7.2 Black body (4)

3.8 Write brief notes on the *film of fluid*. (6)

[50]

QUESTION 4

4.1 Define the following:

4.1.1 Dehumidification (5)

4.1.2 Dew point (4)

4.1.3 Wet-bulb temperature (4)

4.1.4 Humid heat (4)

4.1.5 Saturated air (5)

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4.2 With the aid of humidity formulas, prove that $H_p = H_R \cdot \frac{(P - P_s)}{(P - P_a)} \times 100$ if the molar weight of air is 29 and the molar weight of water is 18. (6)

4.3 Draw a labelled diagram of each of the following cooling towers:

4.3.1 Cross-flow induced draft (5)

4.3.2 Counter-current induced draft (4)

4.4 The partial pressure of water vapour is 65 mm Hg in a mixture of air. The water vapour is at 36 °C and a pressure of 1 atm.

Calculate the mass of the dry air if 9 kg of the mixture is needed to raise the temperature to 41 °C.

Given: $H_a = \frac{18\,P_a}{29\,(P - P_a)}$ (8)

4.5 Calculate the specific heat capacity of steel, if 1,2 MJ of energy is supplied to a steel pipe and the mass of the steel pipe is 2,55 tons with an initial temperature of 198 °C. It reaches a temperature of 496 °C.

Given: $Q = mc\Delta t$ (5)

[50]

TOTAL: 200

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(15040106)

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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STEAM TABLES

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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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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