

073206T4CHE

CHEMICAL ENGINEERING LEVEL 6

ENG/OS/CE/CR/05/6/A

Operate Process Equipment

Nov/Dec 2024



**TVET CURRICULUM DEVELOPMENT, ASSESSMENT AND CERTIFICATION
COUNCIL (TVET CDACC)**

PRACTICE
Ti 2 RS

INSTRUCTIONS TO CANDIDATE:

Do not write on the question paper

DO NOT switch ON power without assessor's permission

Record the required values in the tables provided

Return the question paper to the assessor at the end of practical.

Appendix: Physical and Chemical Data of Alcohol-Water Solution.

This paper consists of SIX (6) printed pages

**Candidates should check the question paper to ascertain that all pages
are printed as indicated and that no questions are missing**

1. You are required to perform the following task

Task 1: Conduct a batch distillation process

2. You are provided with the following resources to perform the task:

a) Apparatus

- i) 1000 mL Distilling flask with rubber stopper
- ii) Thermometer
- iii) Condenser
- iv) Copper tubing
- v) Latex tubing
- vi) Gas stove
- vii) Iron stand
- viii) Graduated plastic collection bottles, 40 ml
- ix) Analytical balance
- x) Specific gravity bottle 25 ml
- xi) Tissue papers
- xii) Volumetric flasks 50 ml
- xiii) Graph paper
- xiv) Plain papers
- xv) Erasable mark pen
- xvi) 50 mL measuring cylinder
- xvii) A cool water bath

b) Reagents

- i) Distilled water
- ii) 600 ml of 10% alcohol solution

PROCEDURE

1. Measurement of parameters of the initial sample

- a) Check every material according to the list, apparatus and equipment and set them aside
- b) Put 40 ml of the initial sample into the measuring cylinder
- c) Measure the temperature of the solution. Record the value in the table

- d) Weigh the specific gravity bottle accurately. Fill the bottle with 25 ml of the sample solution, insert the stopper, remove the spill-over solution with a tissue paper and weigh. Transfer the solution back to the volumetric flask, clean and fill the specific gravity bottle with distilled water and weigh as done for the sample. Calculate the specific gravity of the initial sample and read the alcohol percentage from table of specific gravity vs. alcohol % by volume.

Weight of empty specific gravity bottle = W_1 = ... g

Weight of bottle with sample solution = W_2 = ... g

Weight of bottle with distilled water = W_3 = ... g

Calculate specific gravity using

$$\text{specific gravity} = \frac{\text{weight of sample}}{\text{weight of distilled water}}$$

sample	Volume (ml) / mass (g)	Temperature of sample °C		Specific gravity	alcohol % concentration	Mass fraction of ethanol (calculated)
			distillate is collected			
Initial sample						
1 st distillate						
2 nd distillate						
3 rd distillate						
Final flask mixture						

- e) Once the specific gravity and temperature have been determined, the solution may be discarded

2. Batch Distillation of the Sample

- a) Add 500 ml of the initial sample solution to the 1000 ml distilling flask.
- b) Set up the distillation apparatus correctly
- c) Turn the gas stove setting to medium-high and leave it at this setting to allow the solution to boil
- d) Once the solution begins to boil, place the collection bottle under the pipe to start collecting distillate. Throughout the experiment, ensure that the boil is gentle.
- e) After the first bottle has collected 40 ml of distillate, quickly replace it with an empty one.
- f) Cover and label the bottle containing the first distillate sample as 1st sample. Record the temperature of the vapor phase above the boiling solution.
- g) Determine the mass of the first distillate sample after cooling in to about 40 degrees Celsius. Calculate the specific gravity of the first distillate.
- h) Use the specific gravity value of the alcohol concentration from the data table provided
- i) Record your values in the table a
- j) Discard distillate sample 1 from the specific gravity bottle and rinse it with distilled water.
- k) Repeat the procedure by collecting the second and third distillate sample.
- l) Once you are close to collecting 40 ml of the third distillate, turn the gas stove off and carefully remove the flask from the top of the gas stove.
- m) Leave the distillate collection bottle for about 5 minutes until the mixture in the flask has stopped boiling.
- n) After the third distillate collection bottle has been removed, the flask can be removed from the clamp, and the stopper/tubing apparatus can be detached.
- o) Ensure that the distillation flask is covered while it is cooling.
- p) Once the solution in the flask has cooled to below 40°C, determine the mass of the solution that remains in the flask. Calculate its specific gravity of the solution remaining in the flask using the same method you used for the initial solution.
- q) For each of your samples, use the specific gravity, temperature and Table of the Densities of ethyl alcohol (C₂H₅OH in water) to determine the mass percentage of ethanol in each sample. You may need to use bilinear interpolation to calculate these values.

Calculate the mass fraction of alcohol using

$$x = \frac{\text{mass of sample} \times \text{alcohol \%} \times \text{density}}{\text{mass of sample}}$$

- i) Plot a graph of alcohol mass fraction against temperature.

Comment on the concentrations of your samples

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State one way the experiment can be improved.....

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- ii) Maintain housekeeping of your work area after the experiment

APPENDIX: Physical and Chemical Data of Alcohol-Water Solution.

2-112 PHYSICAL AND CHEMICAL DATA

TABLE 2-110 Ethyl Alcohol (C₂H₅OH)*

%	10°C	15°C	20°C	25°C	30°C	35°C	40°C	%	10°C	15°C	20°C	25°C	30°C	35°C	40°C
0	0.99973	0.99913	0.99823	0.99708	0.99568	0.99406	0.99225	50	0.92126	0.91776	0.91384	0.90985	0.90580	0.90168	0.89750
1	785	725	636	520	379	217	034	51	.91943	555	160	353	.89940	519	
2	602	542	453	336	194	031	.98846	52	723	333	.90936	534	125	710	288
3	426	365	275	157	014	.98849	663	53	502	110	711	307	.89896	479	056
4	258	195	103	.98984	.98839	672	485	54	279	.90885	485	079	667	248	.88823
5	098	032	.98938	817	670	501	311	55	055	659	258	.89850	437	016	589
6	.98946	.98877	780	656	507	335	142	56	.90831	433	031	621	206	.88784	356
7	801	729	627	500	347	172	.97975	57	607	207	.89803	392	.88975	552	122
8	660	584	478	346	189	009	808	58	381	.89980	574	162	744	319	.87888
9	524	442	331	193	031	.97846	641	59	154	752	344	.88931	512	085	653
10	393	304	187	043	.97875	685	475	60	.89927	523	113	699	278	.87851	417
11	267	171	047	.97897	723	527	312	61	698	293	.88882	446	044	615	180
12	145	041	.97910	753	573	371	150	62	468	062	650	233	.87809	379	.86943
13	026	.97914	775	611	424	216	.96989	63	237	.88830	417	.87998	574	142	705
14	.97911	790	643	472	278	063	829	64	006	597	183	763	337	.86905	466
15	800	669	514	334	133	.96911	670	65	.88774	364	.87948	527	100	667	227
16	692	552	387	199	.96990	760	512	66	541	130	713	291	.86863	429	.85987
17	583	433	259	062	844	607	352	67	308	.87895	477	054	625	190	747
18	473	313	129	.96923	697	452	189	68	074	660	241	.86817	387	.85950	407
19	363	191	.96997	782	547	294	023	69	.87839	424	004	579	148	710	266
20	252	068	864	639	395	134	.95856	70	602	187	.86766	340	.85908	470	025
21	139	.96944	729	495	242	.95973	687	71	365	.86949	527	100	667	228	.84783
22	024	818	592	348	087	809	516	72	127	710	287	.85859	426	.84986	540
23	.96907	689	453	199	.95929	643	343	73	.86888	470	047	618	184	743	297
24	787	558	312	048	769	476	168	74	648	229	.85806	376	.84941	500	053
25	665	424	168	.95895	607	306	.94991	75	408	.85988	564	134	698	257	.83809
26	539	287	020	738	442	133	810	76	168	747	322	.84891	455	013	564
27	406	144	.95867	576	272	.94955	625	77	.85927	505	079	647	211	.83768	319
28	268	.95996	710	410	098	774	438	78	685	262	.84835	403	.83966	523	074
29	125	844	548	241	.94922	590	248	79	442	018	590	158	720	277	.82827
30	.95977	686	382	067	741	403	055	80	197	.84772	344	.83911	473	029	578
31	823	524	212	.94890	557	214	.93860	81	.84950	525	096	664	224	.82780	329
32	665	357	038	709	370	021	662	82	702	277	.83848	415	.82974	530	079
33	502	186	.94860	525	180	.93825	461	83	453	028	599	164	724	279	.81828
34	334	011	679	337	.93986	626	257	84	203	.83777	348	.82913	473	027	576
35	162	.94832	494	146	790	425	051	85	.83951	525	095	660	220	.81774	322
36	.94986	650	306	.93952	591	221	.92843	86	697	271	.82840	405	.81965	519	067
37	805	464	114	756	390	016	634	87	441	014	583	148	708	262	.80811
38	620	273	.93919	556	186	.92808	422	88	181	.82754	323	.81888	448	003	552
39	431	079	720	353	.92979	597	208	89	.82919	492	062	626	186	.80742	291
40	238	.93882	518	148	770	385	.91992	90	654	227	.81797	362	.80922	478	028
41	042	682	314	.92940	558	170	774	91	386	.81959	529	094	655	211	.79761
42	.93842	478	107	729	344	.91952	554	92	114	688	257	.80823	384	.79941	491
43	639	271	.92897	516	128	733	332	93	.81839	413	.80983	549	111	669	220
44	433	062	685	301	.91910	513	108	94	561	134	705	272	.79835	393	.78947
45	226	.92852	472	085	692	291	.90884	95	278	.80852	424	.79991	555	114	670
46	017	640	257	.91868	472	069	660	96	.80991	566	138	706	271	.78831	388
47	.92806	426	041	649	250	.90845	434	97	698	274	.79846	415	.78981	542	100
48	593	211	.91823	429	028	621	207	98	399	.79975	547	117	684	247	.77806
49	379	.91995	604	208	.90805	396	.89979	99	094	670	243	.78814	382	.77946	507
								100	.79784	360	.78934	506	075	641	203

*For data from -78° to 78°C, see p. 2-142, Table 2N-5, *American Institute of Physics Handbook*, McGraw-Hill, New York, 1957.

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