Appendices

Appendix I

The international standard for making artificial seawater

The current standard is named ASTM D1141-98 (the original standard was ASTM D1141-52) and describes the standard practice for the preparation of substitute ocean water. ASTM International, founded as the American Society for Testing and Materials, is a nonprofit organization that develops and publishes approximately 12,000 technical standards, covering the procedures for testing and classification of materials of every sort.

Artificial Sea Water Solution	
Material	Composition (g/L)
NaCl	24.53
$MgCl_2$	5.20
Na_2SO_4	4.09
$CaCl_2$	1.16
KCl	0.695
$NaHCO_3$	0.201
KBr	0.101
H_3BO_3	0.027
$SrCl_2$	0.025
NaF	0.003
Water	988.968
Total	1025

Appendix II

Nanofluid preparation

To prepare the nanofluid of a certain volume fraction in a base fluid, the mass of the nanoparticles required was calculated using the bulk density of the material and added to the base fluid

e.g. to prepare copper nanofluid with particle concentration of 0.3% (by volume) in 100 ml water

Density of copper = 8.96 g/ml

Mass of Cu nanoparticles required in 100 ml water = 0.3 ml * 8.96 g/ml = 2.688 g

Therefore, 100 ml, 0.3 volume% Cu nanofluid = 2.688 g Cu nanoparticles + makeup water = total solution volume 100 ml

Appendix III

Sample calculation for determination of solar energy absorption efficiency

This efficiency (η) was taken as the ratio of absorbed radiation to the total radiation incident on the nanofluid solution.

$$\eta = \left[\frac{\left(m_1 c_p (T_2 - T_1) + m_2 \lambda\right)}{I_t . A_c . \rho_r . f_r . \tau_t . t}\right] x\ 100$$

Where, m_1 is mass of initial nanofluid volume in kg, c_p is specific heat of fluid, T_1 is initial temperature of fluid in ^{0}C, T_2 is final temperature of fluid in ^{0}C, m_2 is mass of liquid evaporated in kg, λ is latent heat of vaporization of liquid in J/kg, I_t is solar intensity in W/m^2, A_c is solar collector aperture area, ρ_r is reflectivity of solar collector, f_r is fraction of reflected solar irradiance focused on receiver area, τ_t is transmissivity of glass vessel, t is experiment time in seconds.

e.g. solar energy absorption by using copper nanofluid (0.3%) in water

m_1 = density x volume of water = 1 (g/ml) x 200 ml = 200 g = 0.2 kg

c_p = 4186 J/kg.K

T_1 = 35^{0}C

T_2 = 100^{0}C

m_2 = density x volume of water = 1 (g/ml) x 44 ml = 44 g = 0.044 kg

λ = 2257000 J/kg

I_t = 886 W/m^2

A_c = 1.5 m^2

ρ_r = 0.85

f_r = 0.7

τ_t = 0.9

t = 10 min = 10 x 60 = 600 sec

Therefore,

$$\eta = \left[\frac{(0.2 * 4186(100 - 35) + 0.044 * 2257000)}{886 * 1.5 * 0.85 * 0.7 * 0.9}\right] x\ 100$$

∴ Efficiency of solar energy absorption (η) = 36%

Appendix IV

Concentration (in weight %) of ethanol-water mixture versus specific gravity at various temperatures

wt %	Temperature (degC)				wt %	Temperature (degC)			
Ethanol	20	25	30	35	Ethanol	20	25	30	35
0	0.99823	0.99708	0.99568	0.99406	50	0.91384	0.90985	0.90580	0.90168
1	0.99636	0.9952	0.99379	0.99217	51	0.91160	0.90760	0.90353	0.89940
2	0.99453	0.99336	0.99194	0.99031	52	0.90936	0.90534	0.90125	0.89710
3	0.99275	0.99157	0.99014	0.98849	53	0.90711	0.90307	0.89896	0.89479
4	0.99103	0.98984	0.98839	0.98672	54	0.90485	0.90079	0.89667	0.89248
5	0.98938	0.98817	0.98679	0.98501	55	0.90258	0.89850	0.89437	0.89016
6	0.9878	0.98656	0.98507	0.98335	56	0.90031	0.89621	0.89206	0.88784
7	0.98627	0.98500	0.98347	0.98172	57	0.89803	0.89392	0.88975	0.88552
8	0.98478	0.98346	0.98189	0.98009	58	0.89574	0.89162	0.88744	0.88319
9	0.98331	0.98193	0.98031	0.97846	59	0.89344	0.88931	0.88512	0.88085
10	0.98187	0.98043	0.97875	0.97685	60	0.89113	0.88699	0.88278	0.87851
11	0.98047	0.97897	0.97723	0.97527	61	0.88882	0.88446	0.88044	0.87615
12	0.97910	0.97753	0.97573	0.97371	62	0.88650	0.88233	0.87809	0.87379
13	0.97775	0.97661	0.97424	0.97216	63	0.88417	0.87998	0.87574	0.87142
14	0.97643	0.97472	0.97278	0.97063	64	0.88183	0.87763	0.87337	0.86905
15	0.97514	0.97334	0.97133	0.96911	65	0.87948	0.87527	0.87100	0.86667
16	0.97387	0.97199	0.96990	0.9676	66	0.87713	0.87291	0.86863	0.86429
17	0.97259	0.97062	0.96844	0.96607	67	0.87477	0.87054	0.86625	0.86190
18	0.97129	0.96923	0.96697	0.96452	68	0.87241	0.86817	0.86387	0.85950
19	0.96997	0.96782	0.96547	0.96294	69	0.87004	0.86579	0.86148	0.85710
20	0.96864	0.96639	0.96395	0.96134	70	0.86766	0.86340	0.85908	0.85470
21	0.96729	0.96495	0.96242	0.96973	71	0.86527	0.86100	0.85667	0.85228
22	0.96592	0.96348	0.96087	0.95809	72	0.86287	0.85859	0.85426	0.84986
23	0.96453	0.96199	0.95929	0.95643	73	0.86047	0.85618	0.85184	0.84743
24	0.96312	0.96048	0.95769	0.95476	74	0.85806	0.85376	0.84941	0.84500
25	0.96168	0.95895	0.95607	0.95306	75	0.85564	0.85134	0.84698	0.84257
26	0.96020	0.95738	0.95442	0.95133	76	0.85322	0.84891	0.84455	0.84013
27	0.95867	0.95576	0.95272	0.94995	77	0.85079	0.84647	0.84211	0.83768
28	0.95710	0.95410	0.95098	0.95774	78	0.84835	0.84403	0.83966	0.83523
29	0.95548	0.95241	0.94922	0.94590	79	0.84590	0.84158	0.83720	0.83277
30	0.95382	0.95067	0.94741	0.94403	80	0.84344	0.83911	0.83473	0.83029
31	0.95212	0.94890	0.94557	0.94214	81	0.84096	0.83664	0.83224	0.82780
32	0.95038	0.94709	0.94370	0.94021	82	0.83848	0.83415	0.82974	0.82530
33	0.94860	0.94525	0.94180	0.93825	83	0.83599	0.83164	0.82724	0.82279
34	0.94679	0.94337	0.93986	0.93626	84	0.83348	0.82913	0.82473	0.82027
35	0.94494	0.94146	0.93790	0.93425	85	0.83095	0.82660	0.82220	0.81774
36	0.94306	0.93952	0.93591	0.93221	86	0.82840	0.82405	0.81965	0.81519
37	0.94114	0.93756	0.93390	0.93016	87	0.82583	0.82148	0.81708	0.81262
38	0.93919	0.93556	0.93186	0.92808	88	0.82323	0.81888	0.81448	0.81003
39	0.93720	0.93353	0.92979	0.92597	89	0.82062	0.81626	0.81186	0.80742
40	0.93518	0.93148	0.92770	0.92385	90	0.81797	0.81362	0.80922	0.80478
41	0.93314	0.92940	0.92558	0.92170	91	0.81529	0.81094	0.80655	0.80211
42	0.93107	0.92729	0.92344	0.91952	92	0.81257	0.80823	0.80384	0.79941
43	0.92897	0.92516	0.92128	0.91733	93	0.80983	0.80549	0.80111	0.79669
44	0.92685	0.92301	0.91910	0.91513	94	0.80705	0.80272	0.79835	0.79393
45	0.92472	0.92085	0.91692	0.91291	95	0.80424	0.79991	0.79555	0.79114
46	0.92257	0.91868	0.91472	0.91069	96	0.80138	0.79706	0.79271	0.78831
47	0.92041	0.91649	0.91250	0.90845	97	0.79846	0.79415	0.78991	0.78542
48	0.91823	0.91426	0.91028	0.90621	98	0.79547	0.79117	0.78684	0.78247
49	0.91604	0.91208	0.90805	0.90396	99	0.79543	0.78814	0.78382	0.77946
					100	0.78934	0.78506	0.78075	0.77641

Note: Numbers obtained from Table 3-110 (pg. 3-89) “Perry’s Chemical Engineers’ Handbook”, 6^{th} Edition