

Year 12 Chemistry Semester 2 Exam 2009**Solutions****Part 1**

1	(b)	16	(c)
2	(c)	17	(b)
3	(c)	18	(a)
4	(a)	19	(c)
5	(d)	20	(d)
6	(a)	21	(d)
7	(c)	22	(b)
8	(c)	23	(a)
9	(b)	24	(b)
10	(d)	25	(a)
11	(b)	26	(d)
12	(a)	27	(b)
13	(c)	28	(d)
14	(a)	29	(c)
15	(c)	30	(c)

[60]

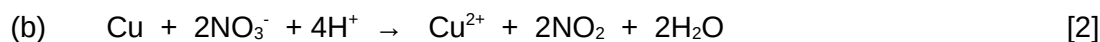
Part 2

1. *Equation:* [1 mark for correct species, 1 mark for balanced equation]
 Do not penalise for missing or incorrect state symbols
 Maximum 1 mark if molecular/formula equation used

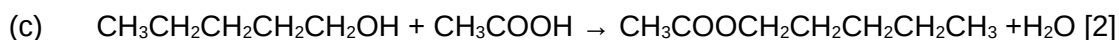
Observations: Need to give 'bulk' of answer for 1 mark
 (at least two observations)



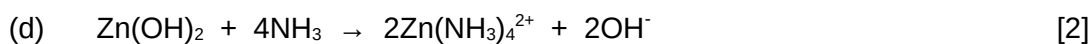
White precipitate forms [1]



The solid dissolves to form a green/blue coloured solution. A brown pungent gas is evolved. [1]



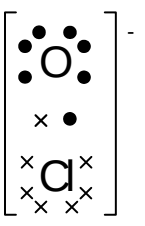
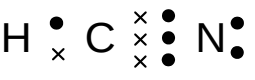
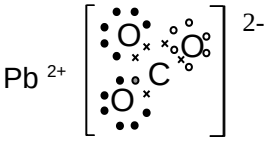
A sweet smelling substance (liquid) is produced. [1]



White solid dissolves to form colourless solution. [1]

[12 marks]

2.

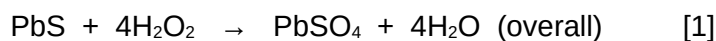
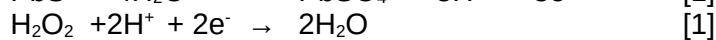
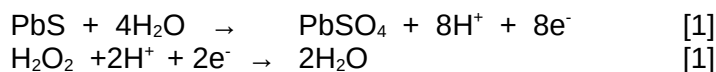
Species	Electron dot structure
Perchlorite ion, OCl^-	
Hydrogen cyanide, HCN	
Lead (II) carbonate PbCO_3	

[2]

[2]

[2]

3.



[6 marks]

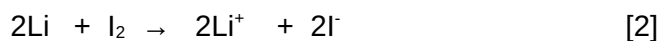
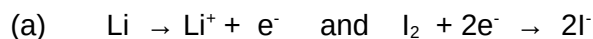
[3 marks]

4.

Ion	Hydrolysis reaction	Acidic (A) or Basic (B) ion.
NH_4^+	$\text{NH}_4^+ + \text{H}_2\text{O} \rightleftharpoons \text{NH}_3 + \text{H}_3\text{O}^+ \quad [1]$	A [1]
CO_3^{2-}	$\text{CO}_3^{2-} + \text{H}_2\text{O} \rightleftharpoons \text{HCO}_3^- + \text{OH}^- \quad [1]$	B [1]

[4 marks]

5.



(b) Water (oxidant) would react with the active metal Li (reductant). [1]

[3 marks]

6.

Intramolecular and intermolecular/ possibly a diagram [1]

Intramolecular – strong, covalent bonding [1]

Intermolecular – strong, hydrogen bonds [1]

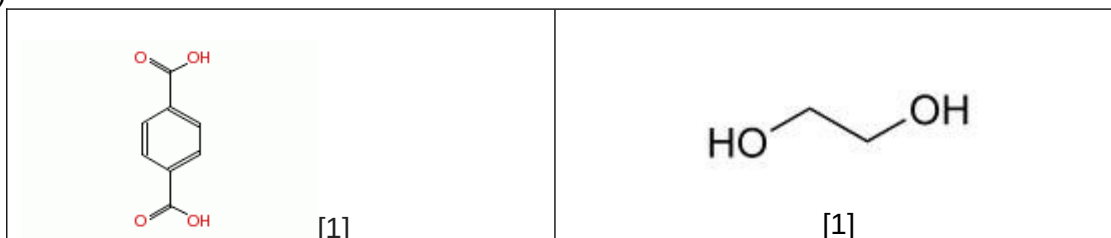
[3 marks]

- 7 (a) fractional distillation [1]
- (b) many possible answers: extraction of metals, fertiliser production, explosives manufacture, cheap base [1]
- (c) Reactant molecules collide with the surface of the catalyst and may become attached to the metal surface [1]
Molecular rearrangements that subsequently occur [bonds break and individual atoms then associate] require less energy [1]
- (d) As temperature increase the rate of collisions increase [1]
With a catalyst less collision energy is required. [1]
With more collisions occurring (higher pressure and temperature) a great proportion of molecules will have sufficient activation energy and be able to form ammonia [1]
- (e) Under pressure the ammonia liquefies and is drawn off; the gases N_2 and H_2 are recycled back into the reaction vessel. [2]

[9 marks]

8.

(a)



- (b) Condensation polymerisation [1]
- (c) No cross linking and weak intermolecular bonding [1]

[4 marks]

9.

Change made to the equilibrium system	Effect on rate of the forward reaction	Effect on the equilibrium yield of Ni(s)
$NH_3(g)$ is removed	DECREASE	INCREASE
Temperature is decreased	DECREASE	INCREASE
An appropriate catalyst is added	INCREASE	UNCHANGED

[6 marks]

10. (a) The copper pipe acts as a cathode [1]
At the point of contact of the copper and iron pipe the iron (anode) will corrode i.e. the attachment of the two different metals facilitates the corrosion of the more active metal (Fe) [1]
- (b) The aluminium is the sacrificial anode [1]
The aluminium corrodes in preference to the Fe superstructure [1]

[4 marks]

11. (a) cryolite lowers the melting point of the alumina [1]
 (b) The fossil fuel used to produce the large amounts of electricity required is coal [1]
 (c) CO_2 [1] and CF_4 [1]

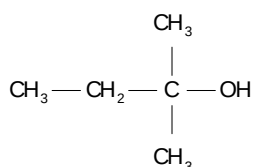
[4 marks]

12. (a)

Name	Structural (or semi structural) formula
3-bromo-2,3-dimethyl-1-pentanal	$ \begin{array}{ccccccc} & & \text{Br} & & & & \\ & & & & & & \\ \text{CH}_3 & - & \text{CH}_2 & - & \text{C} & - & \text{CH} & - & \text{CH} \\ & & & & & & // & & \\ & & \text{CH}_3 & & \text{CH}_3 & & \text{O} & & \end{array} $ <div style="text-align: right;">[2]</div>
cis-1,2-dichloropropene	$ \begin{array}{c} \text{Cl} \quad \quad \text{Cl} \\ \backslash \quad / \\ \text{CH} = \text{C} \\ \quad \quad \\ \quad \quad \text{CH}_3 \end{array} $ <div style="text-align: right;">[2]</div>

(b) 2-methyl-2-butanol

[1]



[1]

- (c) H_2 [1]
 sodium 2-methylbutanoxide [1]

[8 marks]

13. (a) The system has reached equilibrium [1]
 (b) Reactant has been added [1]
 (c) $[(\text{NH}_4)_2\text{S}]$ increased gradually [1]
 $[\text{NH}_3]$ decreased gradually but steeper than $(\text{NH}_4)_2\text{S}$ [1]
 $[\text{H}_2]$ decreased gradually [1]
 (d) A catalyst would make the changes faster and equilibrium would be reached before 2.0 sec [1]

[6 marks]

Part 3

1. (a) $(\text{NH}_4)_2\text{SO}_3(\text{s}) \rightarrow \text{NH}_3(\text{g}) + \text{SO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{g})$ [1]
- (b) $n((\text{NH}_4)_2\text{SO}_3) = 1.54 / 116.154 = 0.01326 \text{ mol}$ [1]
- $n(\text{gas})_{\text{total}} = n(\text{NH}_3) + n(\text{SO}_2) + n(\text{H}_2\text{O})$ [1]
- $n(\text{gas}) = (0.01326) + (0.01326) + (2 \times 0.01326) = 0.05303 \text{ mol}$ [1]
- $P(\text{gas}) = nRT / V$
- $= 0.05303 \times 8.315 \times (302 + 273) / 1.85 = \mathbf{137 \text{ kPa}}$ [1]
- (c) $n(\text{SO}_2) = n((\text{NH}_4)_2\text{SO}_3) = n(\text{CaSO}_3) = 0.01326 \text{ mol}$ [1]
- $m(\text{CaSO}_3) = 0.01326 \times 120.15 = \mathbf{1.59 \text{ g}}$ [1]

[7 marks]

2. (a) $\text{Ca}_3(\text{PO}_4)_2(\text{s}) + 2\text{H}_2\text{SO}_4(\text{aq}) \rightarrow \text{Ca}(\text{H}_2\text{PO}_4)_2(\text{s}) + 2\text{CaSO}_4(\text{s})$ [1]
- (b) $m(\text{Ca}_3(\text{PO}_4)_2)_{\text{pure}} = 0.75 \times 35\,000 = 26\,250 \text{ kg}$ [1]
- $n(\text{Ca}_3(\text{PO}_4)_2)_{\text{pure}} = 26\,250 \times 1000 / 310.18 = 84\,628 \text{ mol}$ [1]
- $n(\text{H}_2\text{SO}_4) = 18.0 \times 15\,000 = 270\,000 \text{ mol}$ [1]
- $n(\text{Ca}_3(\text{PO}_4)_2(\text{s}))_{\text{required}} = \frac{1}{2} \times n(\text{H}_2\text{SO}_4(\text{aq}))_{\text{required}}$ [1]
- Stoichiometric ratio is: 1:2 and actually ratio is approx. 1:3.2
Therefore **LR is $\text{Ca}_3(\text{PO}_4)_2$** [1]
- (c) $n(\text{H}_2\text{SO}_4)_{\text{excess}} = 270\,000 - 2(84\,628) = 100\,743 \text{ mol}$ [1]
- $m(\text{H}_2\text{SO}_4)_{\text{excess}} = 100\,743 \times 98.076 = \mathbf{9.88 \times 10^6 \text{ g}}$ [1]
(9.88 tonnes)
- (d) $n(\text{Ca}(\text{H}_2\text{PO}_4)_2(\text{s}))_{\text{produced}} = n(\text{Ca}_3(\text{PO}_4)_2(\text{s}))_{\text{reacted}}$ [1]
- $n(\text{Ca}(\text{H}_2\text{PO}_4)_2(\text{s}))_{\text{produced}} (\text{if } 80.0\% \text{ efficient}) = 0.80 \times 84\,628$
- $= 67\,702.6 \text{ mol}$ [1]
- $m(\text{Ca}(\text{H}_2\text{PO}_4)_2(\text{s}))_{\text{produced}} (\text{if } 80.0\% \text{ efficient}) = 67\,702.6 \times 234.052 \text{ g}$
- $= \mathbf{15.8 \text{ tonnes}}$ [1]
- (e) To make bone, teeth, ATP, DNA, phospholipids (one of) [1]

[12 marks]

3. (a) $m(\text{C})_{\text{in } 3.22 \text{ g}} = 12.01 / 44.01 \times 5.51 \text{ g} = 1.504 \text{ g}$
 $\%(\text{C}) = 1.504 / 3.22 \text{ g} \times 100\% = \mathbf{46.70\%}$ [1]
 $m(\text{H})_{\text{in } 3.22 \text{ g}} = 2 \times 1.008 / 18.016 \times 1.28 \text{ g} = 0.1432 \text{ g}$
 $\%(\text{H}) = 0.1432 / 3.22 \times 100\% = \mathbf{4.45\%}$ [1]
 $n(\text{NO}_2) = PV / RT = 103 \times 1.12 / (8.315 \times 373)$
 $= 0.03719 \text{ mol}$ [1]
 $m(\text{N})_{\text{in } 1.68 \text{ g}} = 0.03719 \times 14.01 = 0.5211 \text{ g}$
 $\%(\text{N}) = 0.5211 / 1.68 \times 100\% = \mathbf{31.02\%}$ [1]
 $\%(\text{O}) = 100 - (46.70 + 4.45 + 31.02) = \mathbf{17.83\%}$ [1]

	C	H	N	O	
n	46.70 / 12.01	4.45 / 1.008	31.02 / 14.01	17.83 / 16.00	
n	3.888	4.419	2.214	1.114	[1]
n	3.888 / 1.114	4.419 / 1.114	2.214 / 1.114	1.114 / 1.114	[1]
n	3.49	3.97	1.99	1.00	

Therefore **EF (theobromine) = $\text{C}_7\text{H}_8\text{N}_4\text{O}_2$** [1]

- (b) $M(\text{EF}) = 7 \times 12.01 + 8 \times 1.008 + 4 \times 14.01 + 2 \times 16.00$
 $= 180.174$ [1]

Therefore the EF = MF i.e. **MF (theobromine) = $\text{C}_7\text{H}_8\text{N}_4\text{O}_2$** [1]

- (c) Toxicity level (for 8.00 kg dog) = $8.00 \times 300 \text{ mg}$
 $= 2400 \text{ mg}$
 $= 2.40 \text{ g theobromine}$ [1]
 Mass of brand chocolate = $2.40 \times (100 / 2.50)$
 $= \mathbf{96.0 \text{ g}}$ [1]

[12 marks]

4. (a) $[\text{H}^+] = 10^{-1.80} \text{ M} = \mathbf{0.158 \text{ M}}$ [1]
 (b) $\text{Mg}(\text{OH})_2 + 2\text{H}^+ \rightarrow \text{Mg}^{2+} + 2\text{H}_2\text{O}$ [1]
 $\text{Al}(\text{OH})_3 + 3\text{H}^+ \rightarrow \text{Al}^{3+} + 3\text{H}_2\text{O}$ [1]

- (c) $n(\text{Mg}(\text{OH})_2)_{\text{in } 10.00 \text{ mL}} = 0.350 / 58.316$
 $= 6.002 \times 10^{-3} \text{ mol}$ [1]
- $n(\text{Al}(\text{OH})_3)_{\text{in } 10.00 \text{ mL}} = 0.300 / 78.004$
 $= 3.846 \times 10^{-3} \text{ mol}$ [1]
- $n(\text{OH}^-)_{\text{total}} = (2 \times 6.002 \times 10^{-3}) + (3 \times 3.846 \times 10^{-3})$
 $= 0.02354 \text{ mol}$ [1]
- $n(\text{HCl})_{\text{required}} = 0.02354 \text{ mol}$ [1]
- $v(\text{HCl})_{\text{required}} = 0.02354 / 0.158 = 0.149 \text{ L}$
 $= 149 \text{ mL}$ [1]
- (d) stomach bloating or gas, due to the evolution of CO_2 gas [1]

[9 marks]

5. (a) $Q = It = 0.500 \times 250 \times 60 = 7500 \text{ C}$ [1]
 $n(e^-) = 7500 / 96\,490 = 7.773 \times 10^{-3} \text{ mol}$ [1]
 $n(\text{Cu}) = \frac{1}{2} \times n(e^-) = \frac{1}{2} \times 7.773 \times 10^{-3} \text{ mol}$
 $= 0.03886 \text{ mol}$ [1]
 $m(\text{Cu}) = 0.03886 \times 63.55 = 2.47 \text{ g}$ [1]
- (b) mass loss at anode = **2.47 g** [1]
- (c) $[\text{CuSO}_4]_{\text{final}} = 1.50 \text{ M}$ [1]
- (d) $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 12e^- \rightarrow 2\text{Cr} + 7\text{H}_2\text{O}$ [1]
- (e) $n(\text{Cr}) = 5.45 / 52.00 = 0.1048 \text{ mol}$ [1]
 $n(e^-)_{\text{required}} = 6 \times 0.1048 = 0.6288 \text{ mol}$ [1]
 $Q = 0.688 \times 96\,490 = 60\,677 \text{ C}$ [1]
 $t (\text{taken to Cr plate}) = 60\,677 / 2.04 = 29\,743 \text{ s}$
 $= 8.26 \text{ hrs}$ [1]
- (f) $n(\text{CrO}_3)_{\text{required}} = n(\text{Cr})_{\text{used}} = 0.1048 \text{ mol}$ [1]
 $m(\text{CrO}_3)_{\text{required}} = 0.1048 \times (52.00 + 48.00)$
 $= 1.05 \text{ g}$ [1]

[13 marks]

Part 4 (20 Marks) Model Answer

It is not expected that students need to cover all points in order to obtain maximum marks. Credit should be given for accurate use of equations, diagrams and examples. No credit is given for directly repeating information given in the question, nor for areas of chemistry not mentioned in the question.

Chemical equations / reactions

Mostly redox reactions:

- (i) $\text{Mn}^{2+} + 2\text{OH}^- \rightarrow \text{Mn}(\text{OH})_2$
- (ii) $4\text{Mn}(\text{OH})_2 + \text{O}_2 + 2\text{H}_2\text{O} \rightarrow 4\text{Mn}(\text{OH})_3$
- (iii) $\text{Mn}(\text{OH})_3 + 3\text{H}^+ \rightarrow \text{Mn}^{3+} + 3\text{H}_2\text{O}$
- (iv) $(\text{Mn}^{3+} + \text{e}^- \rightarrow \text{Mn}^{2+}) \times 2$
 $2\text{I}^- \rightarrow \text{I}_2 + 2\text{e}^-$
- (v) $\text{I}_2 + \text{starch} \rightarrow \text{"I}_2\text{-starch complex"} \text{ (blue)}$
- (vi) $2\text{S}_2\text{O}_3^{2-} + \text{I}_2 \rightarrow \text{S}_4\text{O}_6^{2-} + 2\text{I}^-$

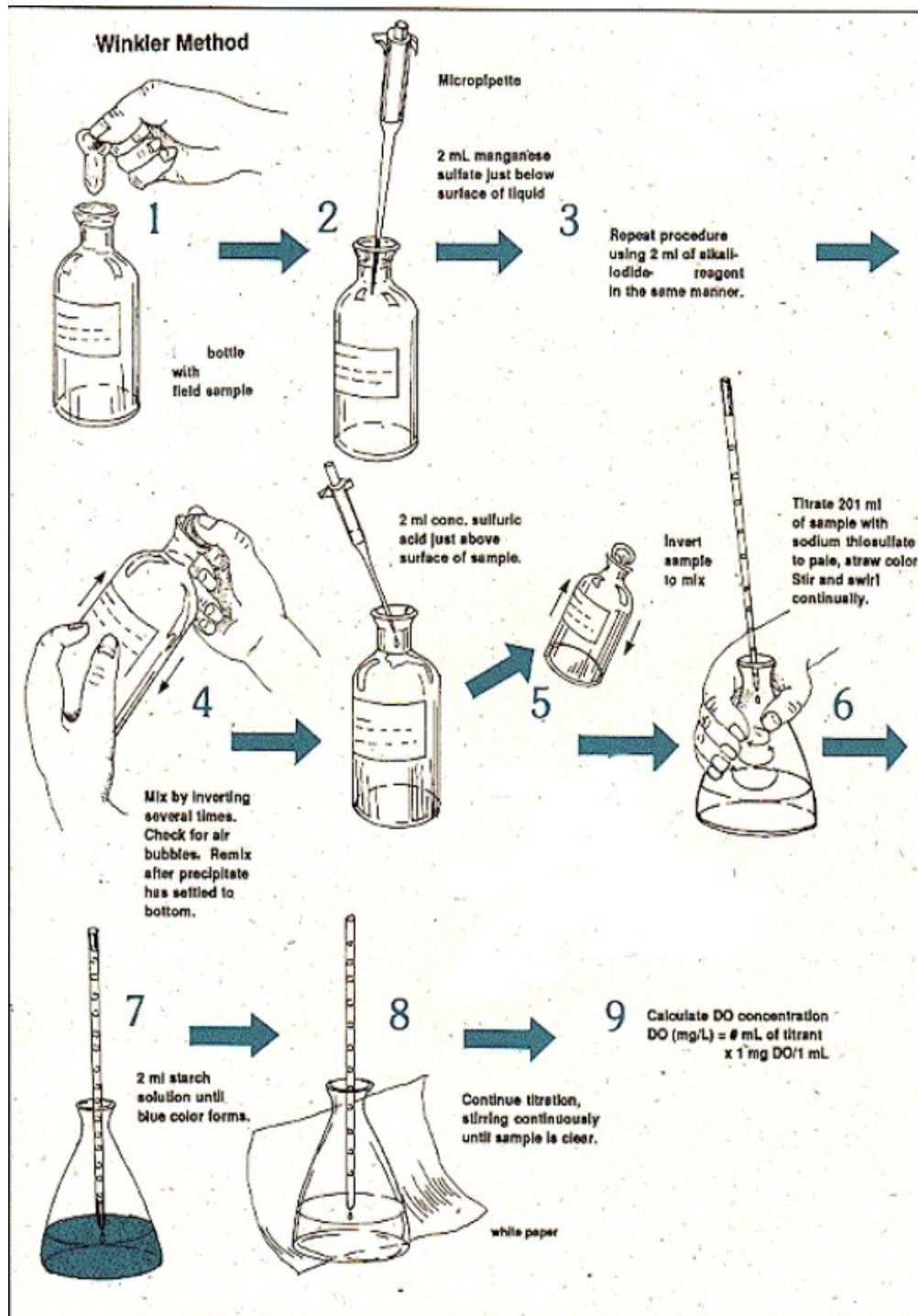
Stoichiometry

$n(\text{dissolved oxygen, O}_2)$ can be mathematically linked to the amount of iodine formed.

Procedure

- At the lake, put on safety gloves (water may be polluted).
- Measure and record the temperature of the lake water (temperature affects oxygen solubility).
- Collect 4 x 300 mL samples of water, full to brim in tightly sealed bottles. Place bottles under water so that no oxygen is lost or added. Label bottles.
- In the laboratory, unscrew lid of bottles and add reagents (MnSO_4 and NaOH) using a graduated pipette. Place the pipette into the solution to avoid adding O_2 from air on solution surface.
 Safety gloves should be worn as some reagents are toxic/irritating to the skin.
- Reseal bottle and invert to mix reagents. A brown solid will settle.
 Added acid will react with the metal hydroxide $\text{Mn}(\text{OH})_3$ to dissolve it. All dissolved O_2 should now be "fixed".
- Both NaI and MnSO_4 solutions would have been prepared by weighing out a given mass of solid (top loading balance) and placing in a volumetric flask. Distilled water is added to take the volume up to the mark (graduation).
- Using a pipette take 20.00 mL aliquots of the solution and place in conical flasks ready for titration.
- Flush out a burette with distilled water and then with a small volume of standardised sodium thiosulfate solution. Set up all glassware and retort stand/burette holder.
- Add starch indicator to each flask and the solution will be blue coloured.
- Titrate each flask, with swirling, until the first drop of excess sodium thiosulfate results in the solution turning colourless (endpoint). Repeat the procedure until concordant results are achieved.
- Repeat steps 4 to 10 with the other water samples (bottles)
- Analyse data and perform calculations to determine the amount of dissolved oxygen in each water sample. Account for any differences.

Diagram / flow chart



Possible errors / limitations

1. Difficulty in not adding or removing dissolved oxygen to/from the samples. Care in handling required. Any bottles with air bubbles in should be discarded.
2. Solutes in the water samples could react with iodine. Give a higher determination of dissolved oxygen. The water samples could be filtered (under water) before being added to sealed bottles.
3. Some sample volume is lost in adding reagents to the full bottles. Small volumes involved only 6 ml compared to 300 mL.
4. Difficult to control water temperature. Any comparisons of dissolved oxygen would need to be made at the same water temperatures.