GEOL3020 Name _____

Oxygen isotope paleothermometry depends on the oxygen isotope difference between the calcium carbonate shells of marine organisms and seawater. Theoretical and experimental tests show that with increasing temperature this difference decreases. If the isotopic composition of the ocean remains constant, then a shell will have an increasingly higher $^{18}O/^{16}O$ ratio as the temperature (T) decreases.

All measurements of oxygen isotopes in paleothermometry are made on carbon dioxide gas released from shells dissolved by acid. The seawater value can be obtained by measuring the value of carbon dioxide equilibrated with seawater. All measurements are made relative to a standard (which by agreement is the Cretaceous belemnite from the Pee Dee Formation in South Carolina) and expressed as $\delta^{18}O$ where:

$$\delta^{18}O = \left[ \frac{\frac{^{18}O}{^{16}O_{samp}}}{\frac{^{18}O}{^{16}O_{std}}} - 1 \right] 10^3$$

The isotopic value is given in parts per mil difference from the standard. The following set of data relates temperature of shell deposition (growth) to the oxygen isotope composition of a shell made of calcite.

| T(°C) | $\delta\,^{18}O_c$ |
|---|---|
| 30 | - 3.14 |
| 25 | - 1.98 |
| 20 | - 0.81 |
| 15 | + 0.35 |
| 10 | + 1.51 |
| 5 | + 2.67 |
| 0 | + 3.84 |

1. Graph the relationship of temperature versus isotope value (Temperature on the *y* axis and $\delta^{18}\,O_c$ on the *x* axis). Remember that the equation for a line is $y = \mathbf{m}x + \mathbf{b}$.

2. From the graph determine the constants **b** and **m** in the straight-line equation having the form:

$$T\,(°C) = \mathbf{m}\,\delta^{18}\,O_c + \mathbf{b}$$

Recall **b** is the $\delta^{18}O_c = 0$ intercept and **m** is the slope of the line ($\Delta T / \Delta\delta^{18}O_c$).

3. The above equation assumes that the seawater value ($\delta^{18}O_w$) on the same scale is zero. Actually the complete equation should be:

$$T\,(°C) = \mathbf{m}\,(\delta^{18}O_c - \delta^{18}O_w) + \mathbf{b}$$

Assume that for the past 11,000 years $\delta^{18}O_w$ has been 0.00 and from 11,000 years BP (Before Present) to 22,000 years BP $\delta^{18}O_w$ was +2.00 (from independent evidence such as ice core data). If a core retrieved from the ocean bottom shows that planktonic foraminifera over the past 22,000 years have a constant $\delta^{18}O_c$ value, then how much did the

temperature of the surface oceans change 11,000 years ago? Hint: You have two unknowns, so you'll need to solve this with two equations.