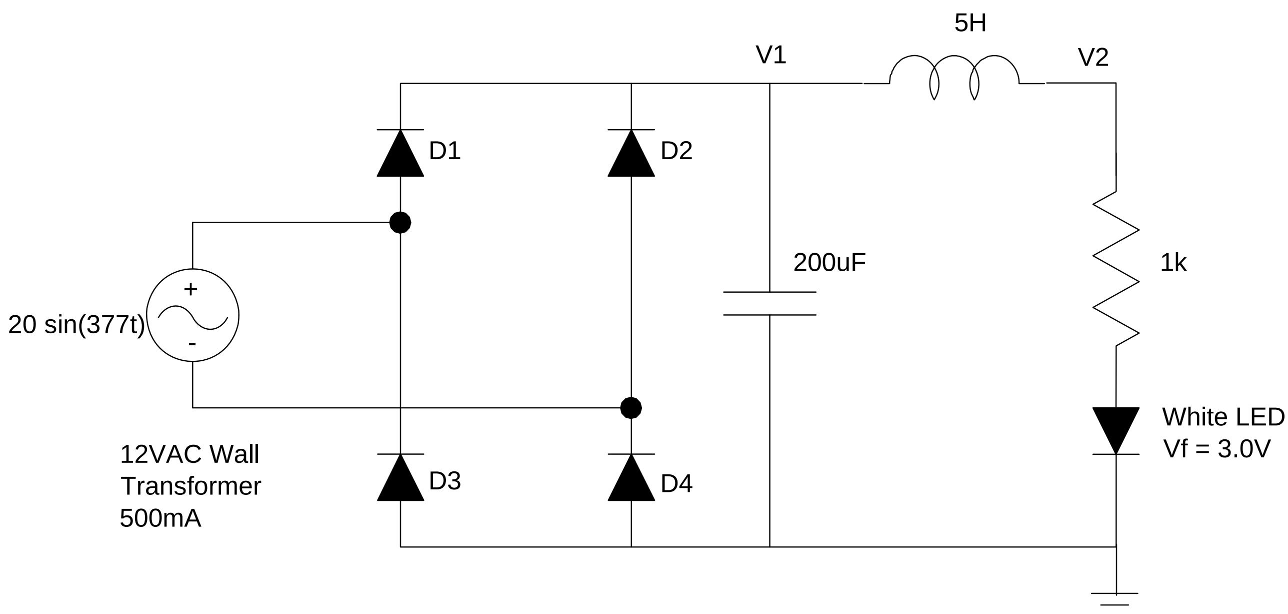
ECE 320 - Quiz #5 - Name ______________________

Full Bridge Rectifier, Transistors, Transistor Switch. September 29, 2017

1) For the following full-bridge rectifier, determine the voltage at V1 and V2

V1 (DC) mean voltage at V1	V1pp (AC) peak-to-peak voltage at V1	V2 (DC) mean voltage at V2	V2pp (AC) peak-to-peak voltage at V2
18.275V	**0.65Vpp**	**18.275V**	**0.166Vpp**



max(V 1) = 20V - 1.4V (two diodes) = 18.6V

Assume V2 = V2 = 18.6V

$$I = \left(\frac{18.6V - 3V}{1k}\right) = 15.6mA$$

To find the ripple (AC)

$$I = C\frac{dV}{dt}$$

$$15.6mA = 200\mu F \cdot \frac{dV}{1/120s}$$

$$dV = 0.65V$$

This tells you that

min(V1) = 18.6V - 0.65V = 17.95V

avg(V1) = avg(18.6, 17.95) = 18.275V

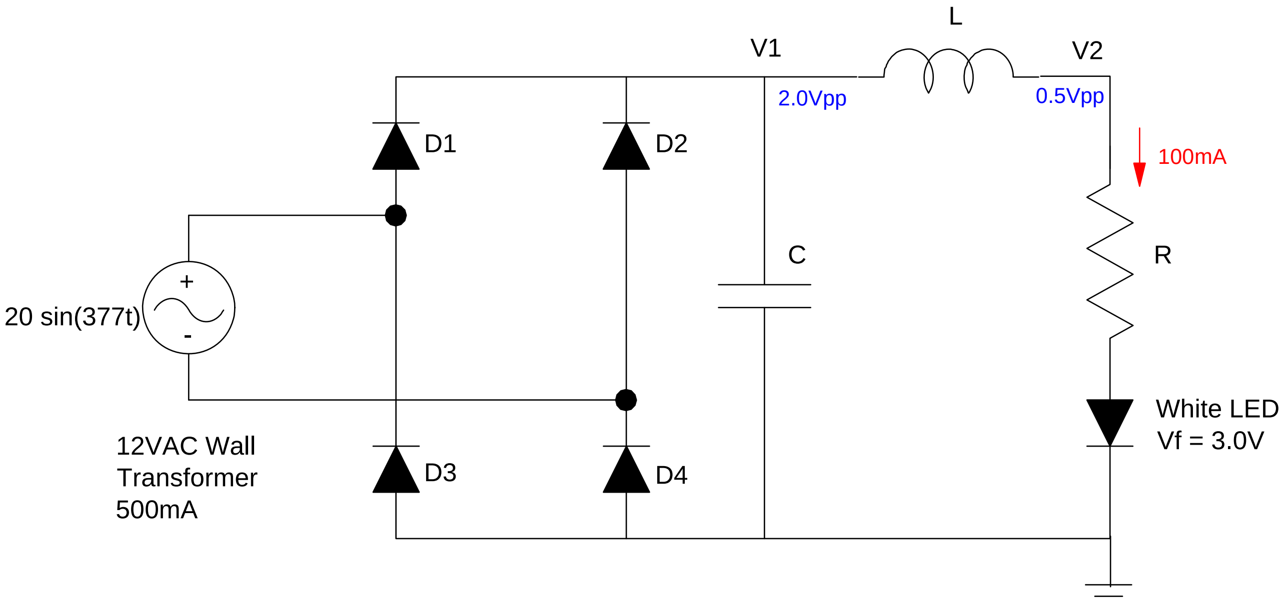
The ripple at V2 is then by voltage division

$$V_2 = \left(\frac{1000}{1000 + j3769}\right) \cdot 0.65V_{pp} = 0.166V_{pp}$$

2) Determine RLC so that the following full-bridge rectifier has

- 100mA flowing through the LED on average
- The ripple at V2 is 0.5Vpp
- The ripple at V1 is 2.0Vpp

R	L	C
146 Ohms	**774 mH**	**417 uF**



max(V1) = 18.6V

min(V1) = 18.6V - 2Vpp = 16.6V

avg(V1) = 17.6V

R:

$$100mA = \left(\frac{17.6V-3V}{R}\right)$$

$$R = 146\Omega$$

C:

$$I = C\frac{dV}{dt}$$

$$0.1A = V \cdot \frac{2V}{1/120s}$$

$$C = 417\mu F$$

L

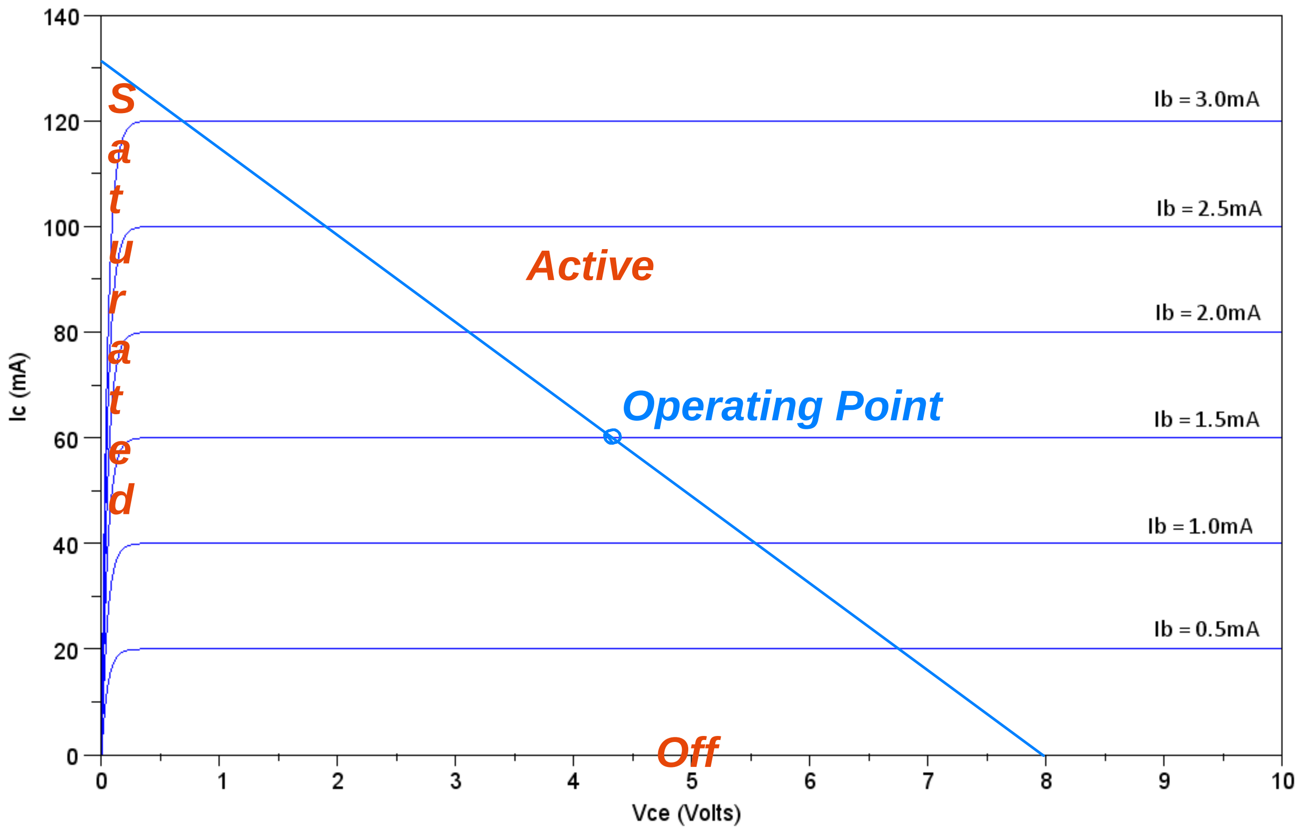
$$\omega L = 4 \cdot 146\Omega$$

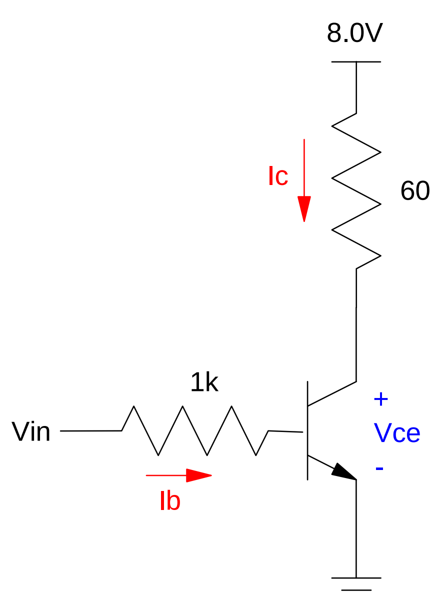
$$\omega L = 584\Omega$$

$$L = 774mH$$

3) The VI characteristics for a transistor are shown below.

Label the regions off / active / saturated regions	Current Gain, Beta Ic = beta * Ib	Load Line	Operating Point when Ib = 1.5mA
Show on graph	**40**	Show on graph	Show on graph

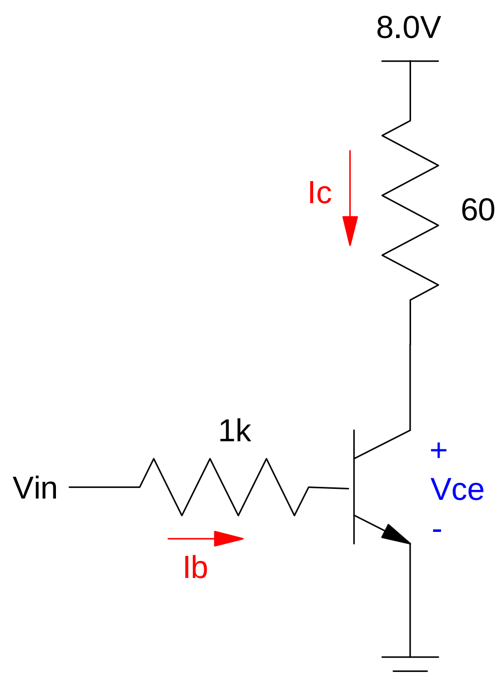




4) Determine the operating point for the following circuit for Vin. Assume

- $\beta = 100$
- $V_{be} = 0.7V$
- $V_{ce(sat)} = 0.2V$

	Vin = 0V	Vin = 3.0V	Vin = 10.0V
Ic	**0**	**130mA**	**130mA**
Vce	**8V**	**0.2V**	**0.2V**



Vin = 3V

$$I_b = \left(\frac{5V - 0.7V}{1k}\right) = 2.3mA$$

$$\beta I_b = 230mA$$

but

$$\max(I_c) = \left(\frac{8V - 0.2V}{60\Omega}\right) = 130mA$$

$$I_c = \min(230mA, 130mA)$$

$$I_c = 130mA$$

Vce = 0.2V

(saturated)

$V_{in} = 10V$

$$I_b = \left(\frac{10 - 0.7}{1k}\right) = 9.3mA$$

$$\beta I_b = 930mA$$

$$I_c = \min(930mA, 130mA)$$

$$I_c = 130mA$$

Vce = 0.2V

(saturated)

5) Determine Rc and Rb so that

- When Vin = 0V, 0mA flows through the LED
- When Vin = +5.0V, 100mA flows through the LED, and
- Ib < 25mA

Assume the transistor has the following characteristics:

- $\beta = 100$
- $V_{be} = 0.7V$
- $V_{ce(sat)} = 0.2V$

Rc	Min value of Rb you could use	Max value of Rb you could use
68 Ohms	**172 Ohms**	**4.3k Ohms**

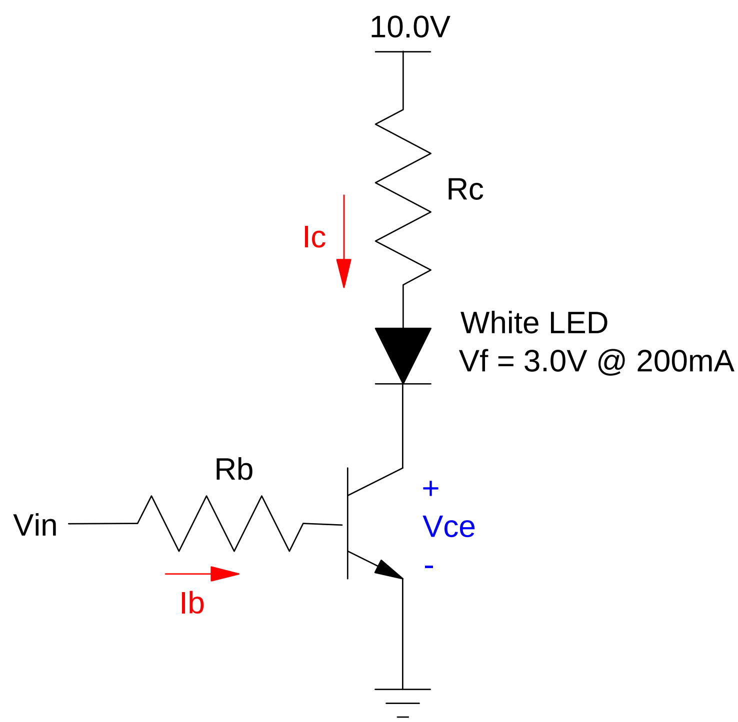
$$R_c = \left(\frac{10-3-0.2}{100mA}\right) = 68\Omega$$

Ib > 1mA

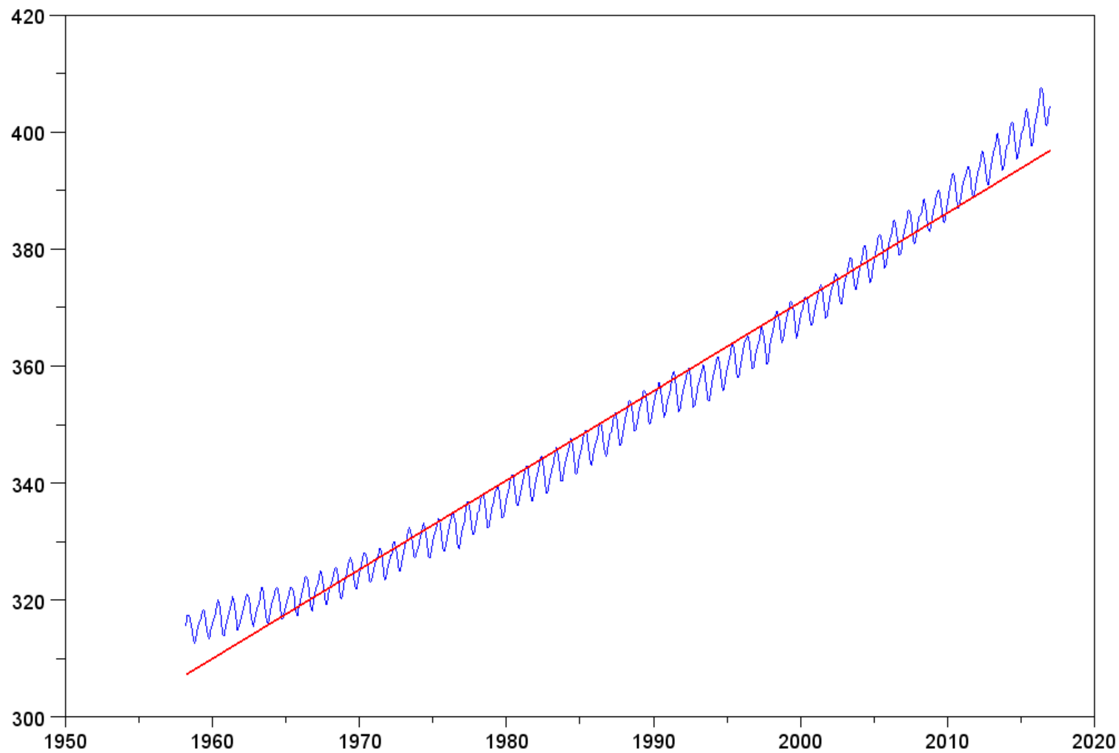
$$R_b = \left(\frac{5V-0.7V}{1mA}\right) = 4.3k\Omega$$

Ib < 25mA

$$R_b = \left(\frac{5V-0.7V}{25mA}\right) = 172\Omega$$



Bonus! Atmospheric CO2 levels have been measured since 1958 on a monthly-basis (plotted below). Based upon this data, when are the CO2 levels going to reach 2000 ppm? (The same level that was observed at the start of the Permian extinction)



Source: https://www.esrl.noaa.gov/gmd/ccgg/trends/full.html

Assume a linear curve fit (meaning the CO2 added to the atmosphere is constant). In Matlab

```
-->DATA = [  (paste in the data) ];
-->y = DATA(:,3);
-->CO2 = DATA(:,5);
```

Set up your basis funciton:

```
-->X = [y,y.^0];
```

Solve using least squares

```
-->A = inv(X'*X)*X'*CO2

    1.5244772
  - 2677.9879
```

meaning

$$CO_2 \approx 1.52 \cdot year - 2677$$

From this curve fit, you'll hit 700ppm (where the ocean currents will stop after 300 years)

```
-->roots(A - [0;700])
    2215.8337
```

You'll hit 2000ppm (the level that triggered the Permian extinction)

```
-->roots(A - [0;2000])
    3068.585
```

(take 2) Assuming a parabolic curve fit (meaning that each year the CO2 added to the atmosphere increases linearly)

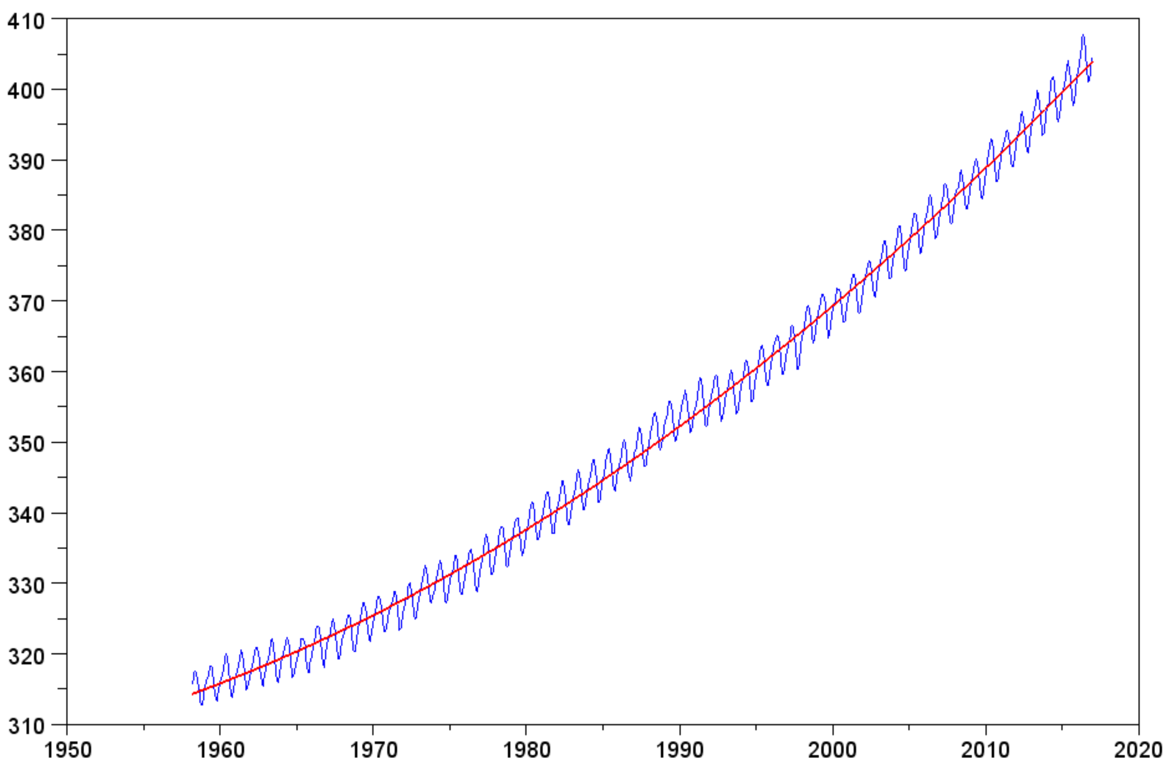
```
-->X = [y.^2,y,y.^0];
-->A = inv(X'*X)*X'*CO2

     0.0123653
   - 47.629524
     46167.283
```

meaning

$$CO_2 \approx 0.0123 \cdot year^2 - 47.62 \cdot year + 46167$$

Checking the result:

```
-->plot(y,CO2,y,X*A)
```



From this curve fit, you'll hit 700ppm in the year 2105. At that point, models predict that it's inevitable that the Gulf stream (and other ocean currents) will grind to a halt. It'll take 300 years for the currents to stop, but at 700ppm, it's inevitable that they will stop.

$$CO_2 = 700 = 0.0123 \cdot year^2 - 47.62 \cdot year + 46167$$

```
-->roots(A - [0;0;700])

     2105.4633
     1746.4164
```

We'll hit 2000ppm in the year 2296. That's the level that triggered the Permian extinction 251 million years ago. That extinction was so complete and brutal that it took 10 million years for life to re-establish itself on Earth.

```
-->roots(A - [0;0;2000])

     2296.5634
     1555.3162
```

What was the Permian Extinction - the last time CO2 levels reached 2000ppm?

Suggested Reading:

- Extinction: How Life on Earth Nearly Ended 250 Million Years Ago (Princeton Science Library) Paperback – March 22, 2015, by Douglas H. Erwin
- When Life Nearly Died: The Greatest Mass Extinction of All Time (Revised edition) Revised edition Edition, 2015, by Michael J. Benton

The Permian Extinction happened 251 million years ago. Up to 96% of all marine species and 70% of terrestrial vertebrates became extinct at that event.

Before the Permian Extinction, life on Earth was thriving. Vast forests, meandering rivers through fertile lands, coral reefs, etc. were common. After the event, nearly all life was gone for 10 million years. The fossil record shows the mud flats of fertile meandering rivers turning in to straight rivers flowing though sand dunes. The vast forests turning into barren landscapes. For 10 million years, almost all fossils disappear: no fish, no reptiles, not even worm traces on the ocean floor.

The cause of the Permian Extinction appears to be the Siberian Traps: a vast eruption with basalt lava flows stretching from the Urals to China.

- The first wave of extinctions came from the sulfur released from the volcanic activity - creating acid rain which killed the forests.
- The second wave came from CO2. The lava flows covered coal beds, which released CO2 into the atmosphere raising CO2 levels to 2000ppm. This in turn raised global temperatures by 10C, creating a second wave of extinctions.
- A warmer Earth resulted in the death of the rain forests - dropping oxygen levels on the planet causing another wave of extinctions.
- Without oxygen, the ozone layer collapsed. Without the ozone layer, UV radiation sterilized the land, killing off exposed land creatures and plants. (more extinctions)
- A warmer Earth melted the ice caps. This in turn resulted in the ocean currents, such as the Gulf Stream, to stop. A stagnate ocean resulted in an oxygen-free environment where cyanide-producing bacteria thrive. This in turn poisoned the atmosphere with cyanide gas, spurring another wave of extinctions.
- Finally, the warmer waters caused methane-hydrates in the ocean to become unstable, releasing methane into the atmosphere, warming the Earth another 10C (20C total). At that point, the ocean at the equator would reach 130F. Simply dipping your foot into the ocean would cause severe burns (if the poisoned atmosphere didn't kill you first).

All this from CO2 levels reaching 2000ppm.

Today, we're running an experiment to see if these conditions can be recreated on Earth.

Do we really want to run this experiment?