LAB REPORT

THE PHOTODIODE AND THE SOLAR CELL

A Report Presented to
The Department of Electrical & Computer Engineering
Concordia University

In Partial Fulfillment
of the Requirements
of ELEC 321

Student Name: **Signature:**

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THE OBJECTIVES:

1. To investigate the characteristics of the Silicon PN-junction in diodes and solar cells.

THE THEORY:

The PN-junction is formed when a P-type and an N-type semiconductor are brought together in an intimate contact.

When the P-type and the N-type semiconductors brought together, diffusion of the majority carriers of each type (electrons diffuse from the N-type to the P-type and holes diffuse from the P-type to the N-type) will start due to the large differences in carrier concentrations. The majority carriers in the vicinity of the junction edge will be the first to migrate (diffuse). Each one of those diffusing majority carriers will leave behind one uncompensated ionized impurity atom, diffusing electrons will leave behind positively charged (e.g. Phosphorous) ions and holes will leave negatively charged (e.g. Boron) ions creating a region called “depletion region” or “space charged region”. The diffusing majority carriers reach the opposite region (electrons reaching the P-type and holes reaching the N-type) become minority carriers and start to recombine with the majority carriers of that region. The uncompensated ions induce an electric field and a potential difference (called built-in potential) between the two regions, which reduce the diffusion of the majority carriers and increase the drift of minorities from one side to the other. This process continues until equilibrium reaches between the diffusion of majority and the drift of minority carriers.

The Photodiode:

A Photodiode is a PN-junction diode that has been specifically fabricated and encapsulated to permit light penetration into the vicinity of the metallurgical junction. When we apply a reverse bias voltage (V_R) to the terminals of the PN-junction Diode, as shown in figure 2-a, the depletion region width will increase as illustrated in figure 2-b.

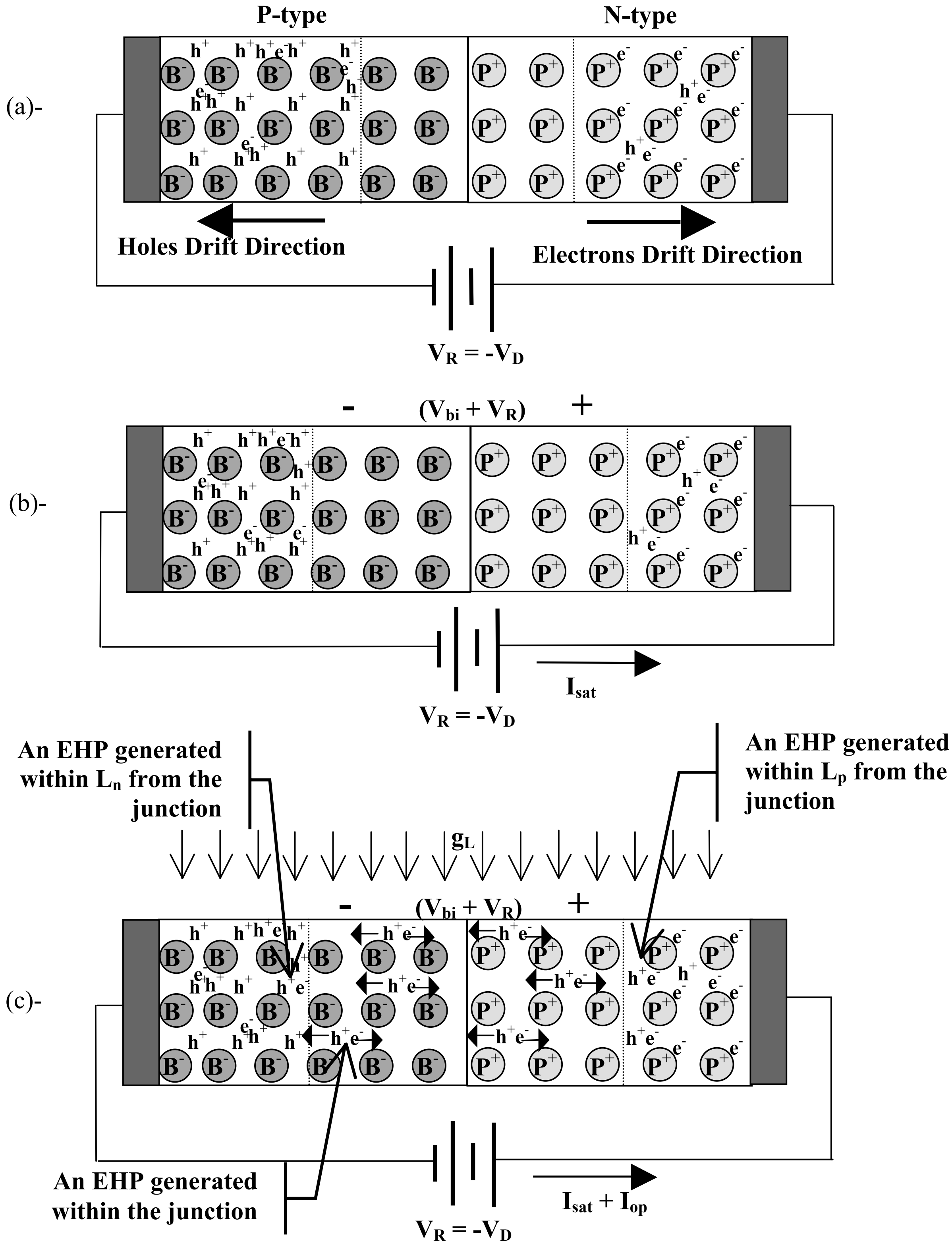

(a)-
P-type
N-type
Holes Drift Direction
Electrons Drift Direction
V_R = -V_D
(b)-
(V_bi + V_R)
I_sat
V_R = -V_D
(c)-
An EHP generated within L_n from the junction
An EHP generated within L_p from the junction
g_L
(V_bi + V_R)
An EHP generated within the junction
V_R = -V_D
I_sat + I_op

Figure 2

As a result, the diffusion current decreases while the drift current remains almost constant. The drift current will constitute a reverse current across the junction. Ideally, for $V_R \geq 5\ V_T$ ($V_R \geq$0.13volts @ 25.0°C), the diode current will be constant ($I_D = -I_{sat}$).

Now, if we apply light over the diode and let the system reach steady state conditions, then an optical generation (g_L, EHP/sec·cm^3) of Electron Hole Pairs (EHP) will uniformly occur all over the volume of the diode. For EHP's generating within the depletion region, the electrical filed of the depletion region will sweep the electrons towards the N-type region and holes towards the P-type region of the diode. This in fact will add as a new current component with a magnitude of ($q \cdot A \cdot W \cdot g_L$), where W is the width of the depletion region at that certain bias voltage. The other current component will come from minority carriers optically generated within a diffusion length (L_p,L_n) from the edge of the depletion region. The magnitude of this current component is $q \cdot A \cdot (L_p + L_n) \cdot g_L$.

The Solar Cell:

A Solar Cell is a combination of several semiconductor PN-junction diodes, which is used to transform Optical Energy into electrical power. In other words, the solar cell will transfer light into voltage and current. And since it's an energy transformer, then the solar cell must be designed of course to minimize energy losses. Hence, solar cell must maintain relatively high efficiency. In this experiment we will be testing a solar cell, which has 12 polysilicon diodes, connected in series.

There are four characterizing parameters for the solar cell, and they are as follows:

V_{oc}: the Open-Circuit voltage.

I_{sc} : the Short-Circuit current.

V_m, I_m : the operating point voltage and current yielding the maximum power output.

Where:

$$I_{sc} = I_{op} = q \cdot A \cdot (W + L_p + L_n) \cdot g_L$$

$$V_{oc} = \left(\frac{kT}{q}\right) \cdot \ln\left[\left(\frac{I_{sc}}{I_{sat}}\right) + 1\right] \qquad (1)$$

Obviously, V_{oc} is the maximum voltage that can be supplied by the cell for the given photo-input, I_{sc} is the maximum current that can be derived from the cell, and $P_{max} = I_m \cdot V_m < I_{sc} \cdot V_{oc}$. Using these four parameters (I_m, V_m, I_{sc}, and V_{oc}), we will obtain the fill-factor.

The FILL-FACTOR is given by:

$$FF = \left[\frac{P_{\max}}{(I_{sc} \cdot V_{oc})}\right] = \left[\frac{(I_m \cdot V_m)}{(I_{sc} \cdot V_{oc})}\right] \qquad (2)$$

QUESTIONS:

1- Underline the main characteristics of a) Photodiode and b) Solar Cell

2- Tabulate the values of the FF for the optical generation conditions used in this experiment.

3- Graph the results obtained for all 3 Light sources.

DATA SHEET:

<u>Light = G1:</u>

R_L=

Ch A: (V/div) = Ch B: (V/div) =

Point #	**Ch A: Voltage**	**Ch B: Voltage/R_L**
1		
2		
3		
4		
5		
6		
7		

Light = G2:

R_L=

Ch A: (V/div) = Ch B: (V/div) =

Point #	**Ch A: Voltage**	**Ch B: Voltage/R_L**
1		
2		
3		
4		
5		
6		
7		

Light = G3:

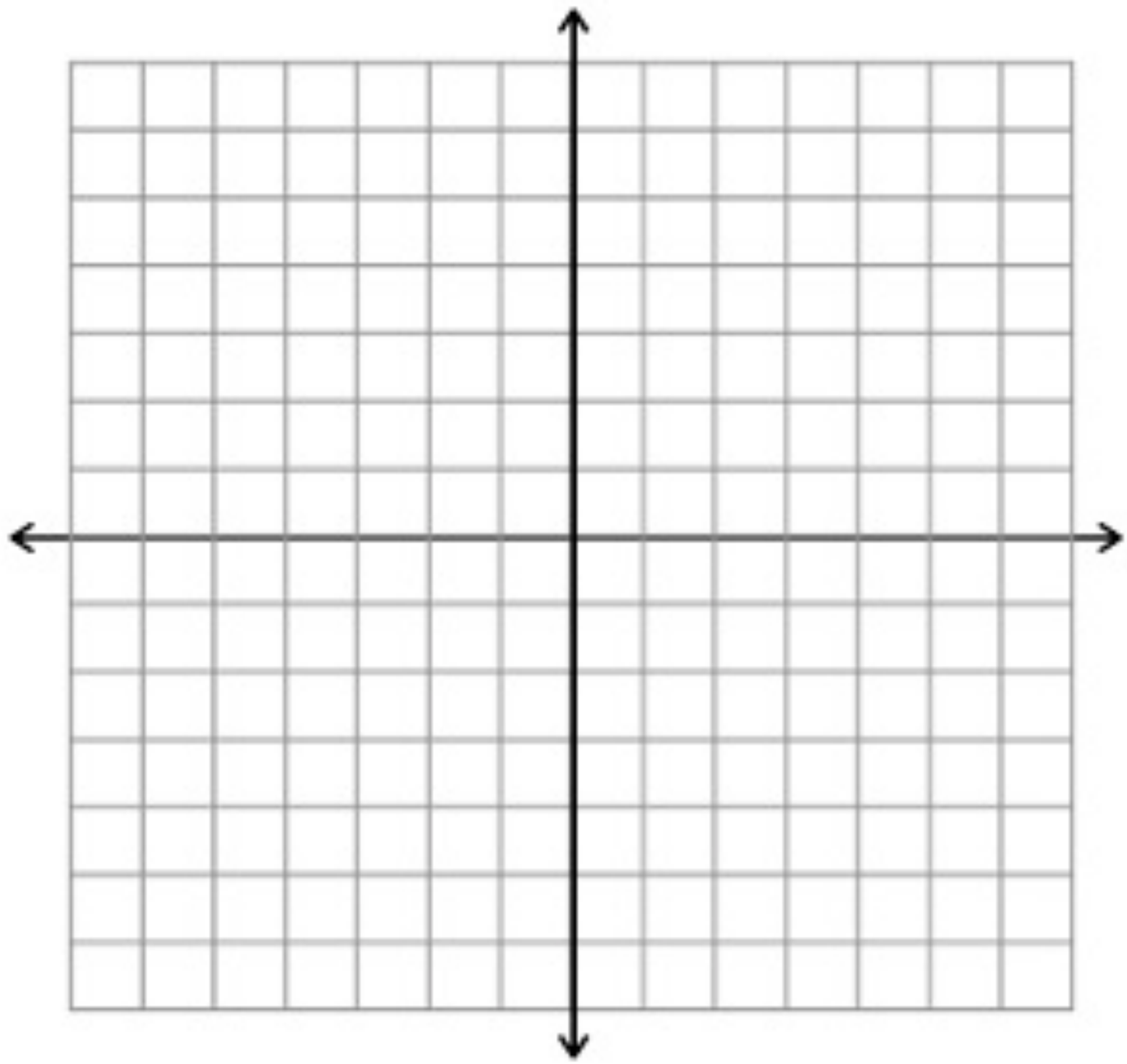
R_L=

Ch A: (V/div) = Ch B: (V/div) =

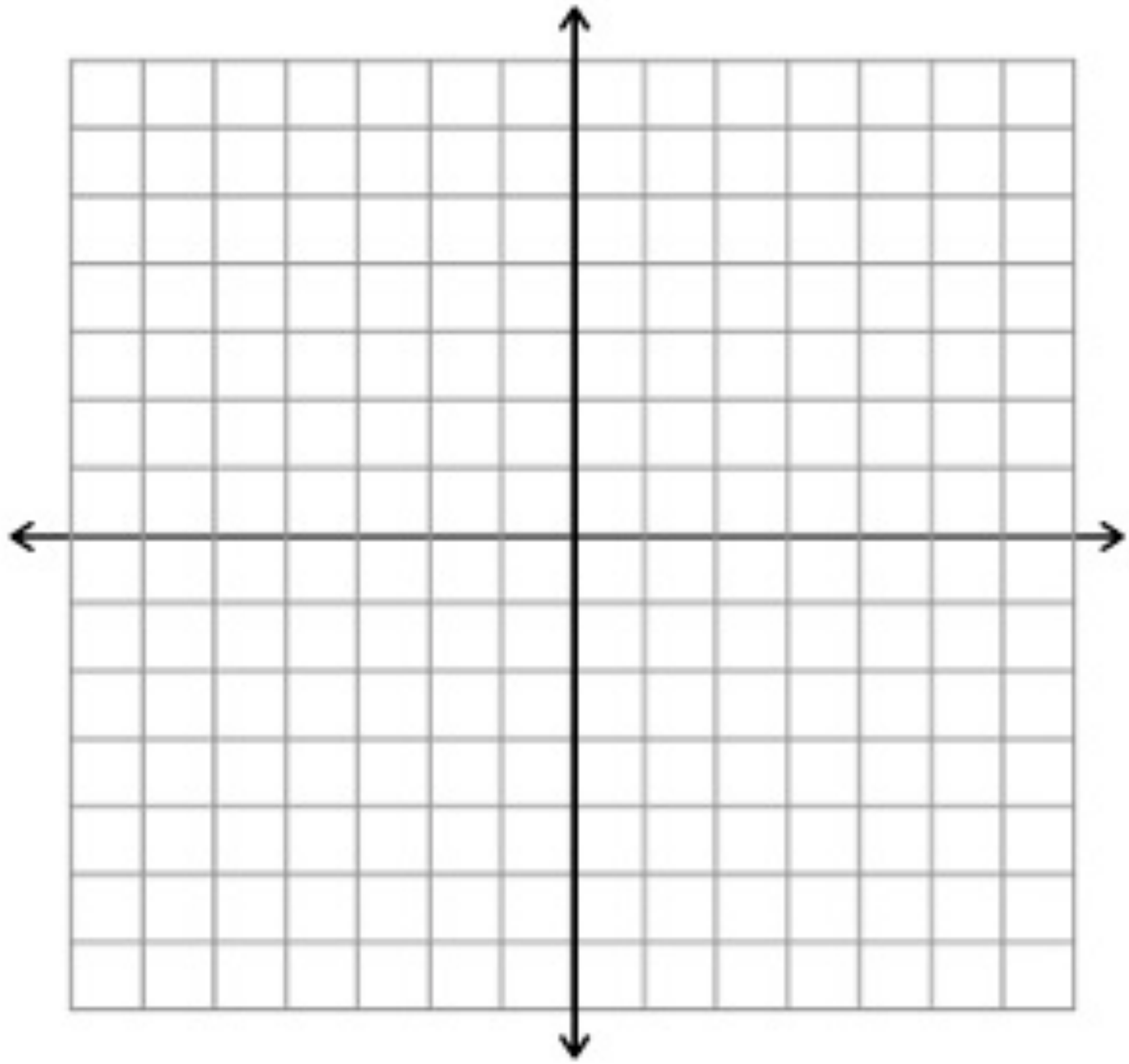
Point #	**Ch A: Voltage**	**Ch B: Voltage/R_L**
1		
2		
3		
4		
5		
6		
7		

GRAPHS:

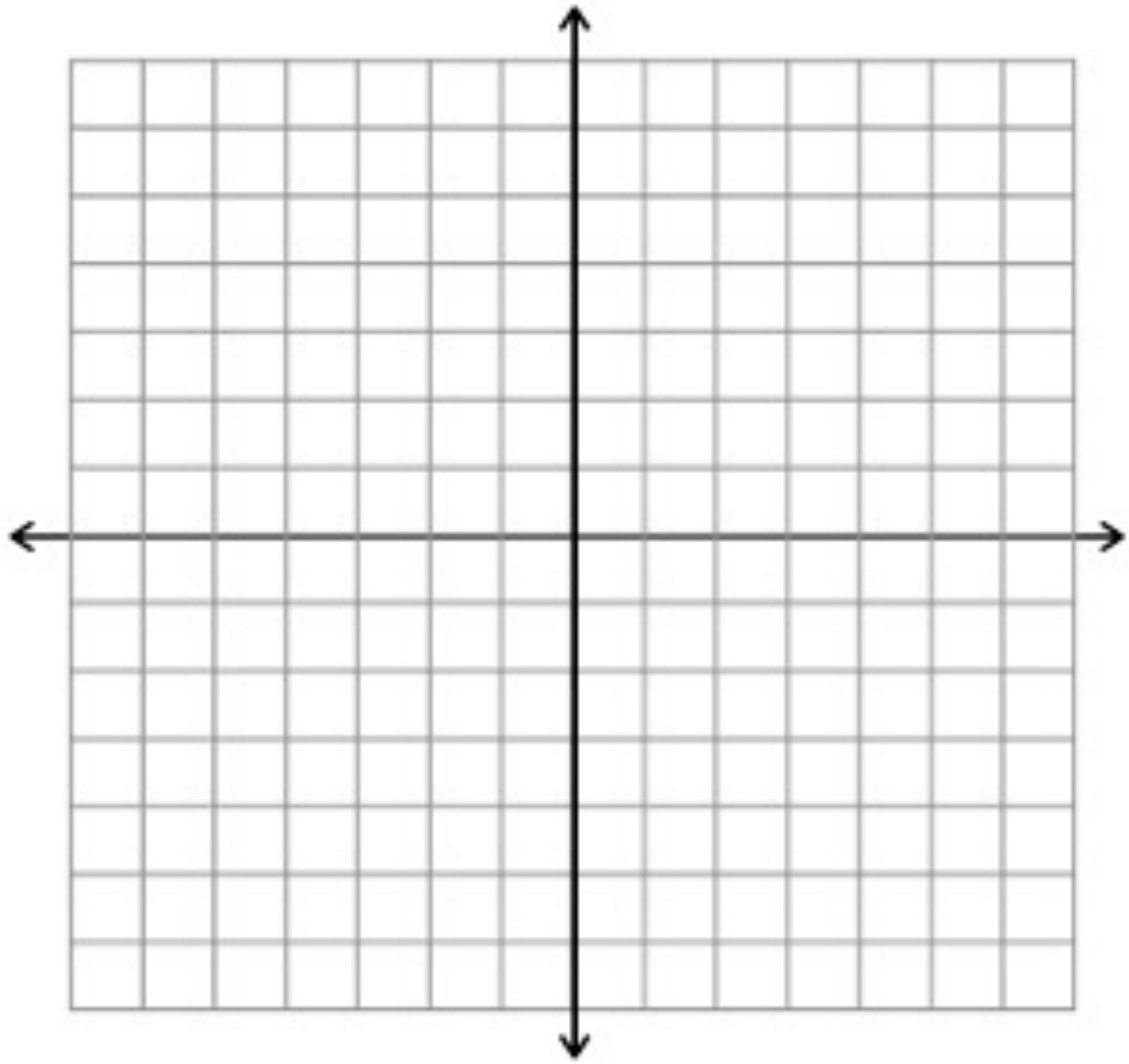
Light = G1:



Light = G2:



Light = G3:



GRADING SCHEME:

QUESTIONS: **TEAMWORK:**

1 – A ____________

+

1 – B ____________

+

2 ____________

+

3 ____________ + ____________________

TOTAL: ________________