

## ملخص 2 الدرس الثاني wave Matter من الوحدة 22 MODULE Quantum انسباير منهج Theory and the Atom



تم تحميل هذا الملف من موقع المناهج الإماراتية

موقع المناهج ← المناهج الإماراتية ← الصف الثامن ← الإمارات ← الفصل الثالث ← ملفات متنوعة ← الملف

تاريخ إضافة الملف على موقع المناهج: 09:59:45 2026-04-02

ملفات اكتب للمعلم اكتب للطالب | اختبارات الكترونية | اختبارات | حلول | عروض بوربوينت | أوراق عمل  
منهج انجليزي | ملخصات وتقارير | مذكرات وبنوك | الامتحان النهائي للمدرس

المزيد من مادة  
الإمارات:

إعداد: Atef Mohamed

التواصل الاجتماعي بحسب الصف الثامن



صفحة المناهج  
الإماراتية على  
فيسبوك

الرياضيات

اللغة الانجليزية

اللغة العربية

التربية الاسلامية

المواد على تلغرام

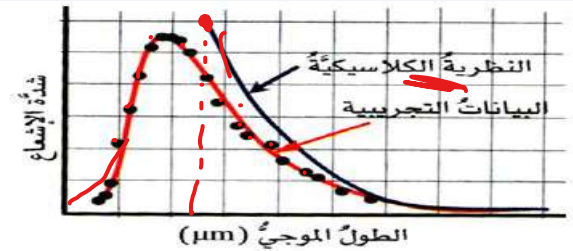
المزيد من الملفات بحسب الصف الثامن والمادة الإمارات في الفصل الثالث

# QUANTUM THEORY AND THE ATOM

## Planck's Theory (Simple Explanation)

### Planck's Main Ideas

1. Atoms cannot change their energy continuously.



الذرات غير قادرة على تغيير طاقتها بشكل مستمر.

2. The vibrational energy of atoms in a solid has only specific (discrete) frequencies, given by:

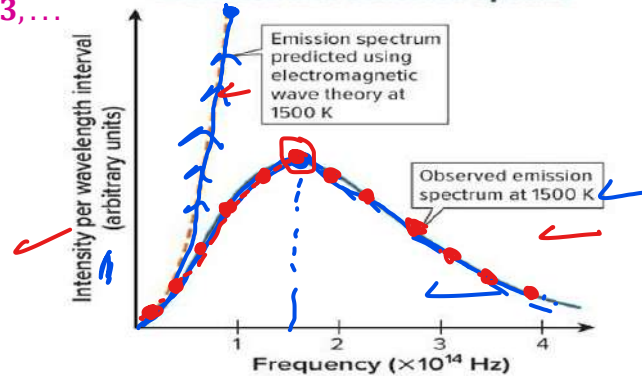
طاقة اهتزاز الذرات في الجسم الصلب لها ترددات محددة فقط، وتُعطى بالعلاقة:

$$E = nhf (n = 0, 1, 2, 3, \dots)$$

This means the energy of a vibrating atom equals: an integer  $\times$  Planck's constant  $\times$  frequency.

- $h =$  Planck's constant  
 $h = 6.63 \times 10^{-34} \text{ "J}\backslash\text{HZ"}$
- $f =$  frequency
- $n =$  whole number (0,1,2...)

Predicted and Observed Spectra



3. Energy is quantized, meaning it exists in discrete packets (quanta):

الطاقة مكمّاة، أي توجد على شكل حزم (كمّات):

$$E = 0, hf, 2hf, 3hf, \dots$$

$$(n = 0, 1, 2, \dots)$$

4. An atom emits electromagnetic radiation only when it transitions from one energy level to another,

which is contrary to Maxwell's assumption. The emitted energy is:

$$\Delta E = E_2 - E_1$$

How does the vibration frequency of an atom change if it emits energy equal to  $5.44 \times 10^{-19} \text{ J}$ ,

given that  $n = 1$  and Planck's constant is

$$h = 6.63 \times 10^{-34} \text{ J}\cdot\text{s?}$$

Using the equation:

$$E = nhf \Rightarrow f = E/nh$$

$$f = (5.44 \times 10^{-19}) / (1 \times 6.63 \times 10^{-34}) = 8.2 \times 10^{14} \text{ " Hz"}$$



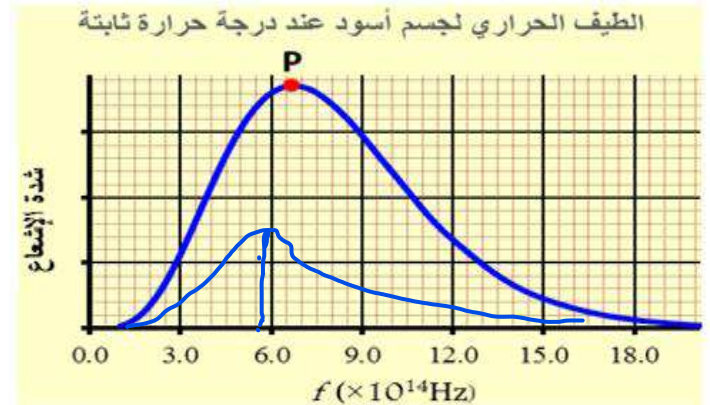
# QUANTUM THEORY AND THE ATOM

The graph shows the intensity of thermal radiation emitted by a blackbody at different frequencies of the emitted electromagnetic spectrum.

Explain what happens to the frequencies of the emitted electromagnetic spectrum when the temperature of the blackbody decreases.

يوضح الرسم البياني شدة الإشعاع الحراري المنبعث من جسم أسود عند ترددات مختلفة من الطيف الكهرومغناطيسي المنبعث. اشرح ماذا يحدث لترددات الطيف الكهرومغناطيسي المنبعث عندما تنخفض درجة حرارة الجسم الأسود.

decrease  $T \rightarrow$  decrease  $f$   
 $\rightarrow$  decrease  $p$



What does an increase in the area under the curve (Intensity – Wavelength) indicate for a blackbody?

ماذا يدل ازدياد المساحة تحت المنحنى (الشدة – الطول الموجي) لجسم أسود؟

- The temperature of the body decreases and the peak wavelength  $\lambda_p$  decreases
- The temperature of the body decreases and the peak wavelength  $\lambda_p$  increases
- The temperature of the body increases and the peak wavelength  $\lambda_p$  decreases
- The temperature of the body increases and the peak wavelength  $\lambda_p$  increases

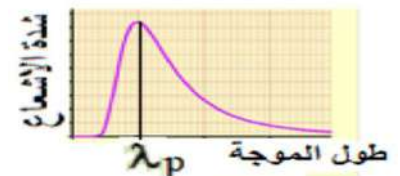
The graph represents the radiation intensity emitted by a blackbody at a certain moment for a specific wavelength.

If the heating of the blackbody continues, what happens to each of the following: the area under the curve and the peak wavelength  $\lambda_p$ ?

يمثل الرسم البياني شدة الإشعاع المنبعث من جسم أسود عند لحظة معينة ولطول موجي محدد.

إذا استمر تسخين الجسم الأسود، ماذا يحدث لكلٍ من المساحة تحت المنحنى الطول الموجي عند القمة

- Both the area and  $\lambda_p$  increase
- Both the area and  $\lambda_p$  decrease
- The area increases and  $\lambda_p$  decreases
- The area decreases and  $\lambda_p$  increases



# QUANTUM THEORY AND THE ATOM

نظرية الكم

## The Photoelectric Effect (Electromagnetic Emissions)

### Definition of the Photoelectric Effect:

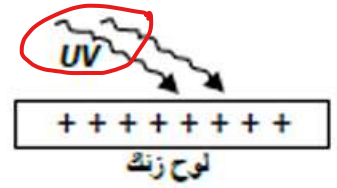
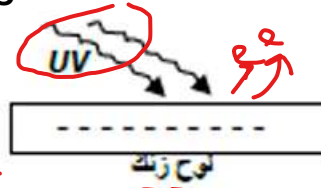
The emission of electrons from the surface of metals when exposed to electromagnetic radiation of suitable frequency.

ظاهرة انبعاث الإلكترونات من سطح الفلزات عند تعرضها لإشعاع كهرومغناطيسي ذو تردد مناسب.

### Difficulties Faced by Maxwell's Wave Theory:

Maxwell's wave theory could not explain the following phenomena:

1. When ultraviolet rays fall on a negatively charged metal plate, it loses its charge; but when visible light falls on it, it does not lose its charge.
2. When ultraviolet rays fall on a positively charged metal plate, the plate remains positively charged and does not lose its charge.



### The Photoelectric Cell

A photoelectric cell is a device used to study the phenomenon of the photoelectric effect.

### Structure of the Photoelectric Cell

#### Two Electrodes (Cathode and Anode):

1. **Cathode (Emitter):**
  - The larger electrode.
  - Made of a thin, curved metal plate coated with cesium or another alkali metal.
  - It has low thickness so it does not block the incident radiation from reaching the cathode surface.
2. **Anode (Collector):**
  - The smaller electrode.
  - Made of a thin metal wire that collects the emitted electrons.
3. A glass tube from which air has been removed, made of quartz



### Reasons for Using These Materials

Mr. Mohamed atef



0503 136836



# QUANTUM THEORY AND THE ATOM

## 1. Removing the air from the photoelectric cell: تفريغ الهواء في الخلية الكهروضوئية:

- To prevent oxidation of the metal surface.
- To prevent electrons from losing energy due to collisions with air molecules.
  - لمنع تأكسد سطح الفلز.
  - لمنع فقد الإلكترونات طاقتها بسبب تصادمها مع جزيئات الهواء.



## 2. Why is quartz used instead of glass? استخدام أنبوب من الكوارتز:

- Because quartz allows ultraviolet radiation to pass through, while ordinary glass absorbs it.
- للسماح بمرور الأشعة فوق البنفسجية، لأن الزجاج العادي يمتصها.

## 3. Why is the anode made of a very thin wire? جعل المصعد (القطب الموجب) من سلك رفيع جداً.

- To allow radiation to pass through and avoid blocking it.
- حتى يسمح بمرور الإشعاع ولا يحجب إلا كمية صغيرة منه.

## How the Photoelectric Cell Works

1. If no electromagnetic radiation falls on the cathode:

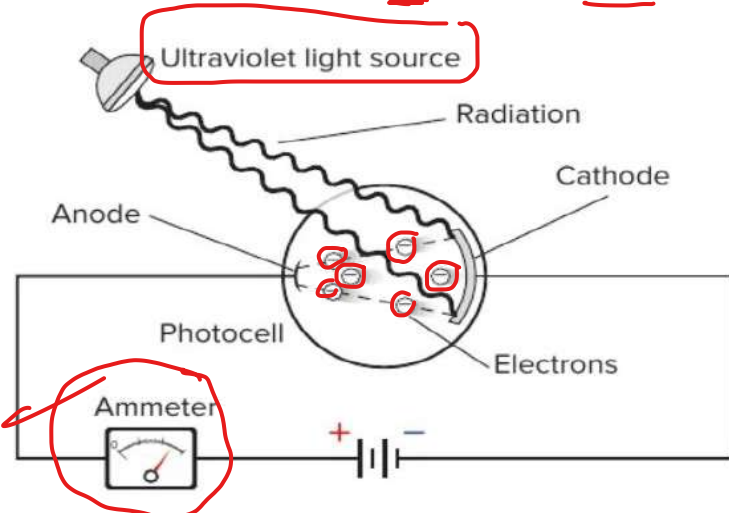
☞ No electric current flows (the circuit is open)..

$$f < f_0$$

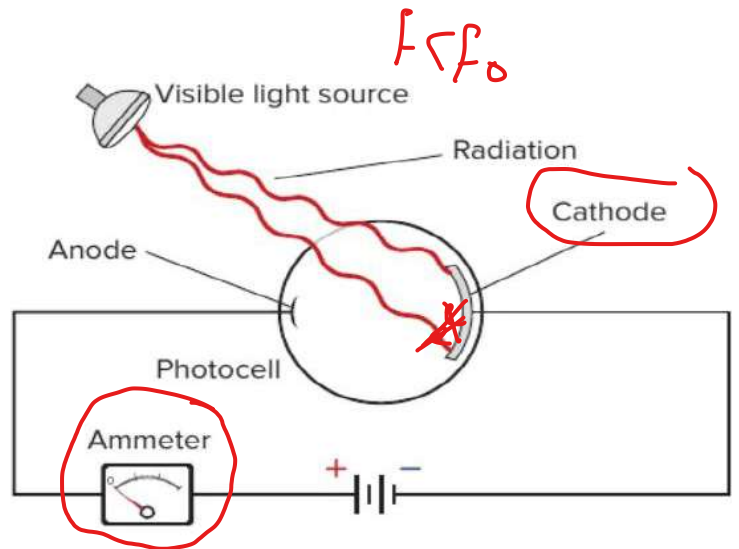
2. If light with frequency  $f$  falls on the cathode such that:

$$f \geq f_0$$

- ☞ Electrons are emitted from the cathode.
- ☞ They move toward the anode.
- ☞ An electric current is produced and measured.



The photoelectric effect is demonstrated by the photocell illuminated by ultraviolet light.



The same photocell, illuminated by visible light, does not display the photoelectric effect.



# QUANTUM THEORY AND THE ATOM

## Important Notes



1. The threshold frequency depends on the type of metal used for the cathode.
2. The current **does not depend** on the energy of the electrons (their speed). It depends only on the number of emitted electrons.
3. Increasing the intensity of the radiation increases the current **only if the light frequency is greater than the threshold frequency of the metal.**

1. يعتمد تردد العتبة على نوع المعدن المستخدم في الكاثود.

2. لا يعتمد التيار على طاقة الإلكترونات (سرعتها)، بل يعتمد فقط على عدد الإلكترونات المنبعثة.

3. زيادة شدة الإشعاع تزيد التيار فقط إذا كان تردد الضوء أكبر من تردد العتبة للمعدن.

$$F \geq F_0$$

## Explain the following:

1. Cesium electrons can be emitted by all visible colors except red.

$$F < F_0$$

Because red has the lowest frequency in the visible spectrum and therefore does not have enough energy to release electrons from the metal.

Oppositely, the other visible colors have higher frequencies and therefore have enough energy to release cesium electrons.

2. Electrons cannot be emitted from metal surfaces when exposed to red light.

$$F_{red} < F_0$$

Because the frequency of red light is lower than the threshold frequency required to release electrons from the metal.

3. When ultraviolet radiation falls on a negatively charged metal plate, the plate loses its negative charge.

$$F > F_0$$

Because ultraviolet radiation has high frequency and therefore high energy, which allows it to release the electrons responsible for the negative charge.

## Why Maxwell's Theory Failed:

It says light energy depends on intensity, not frequency.

تقول إن طاقة الضوء تعتمد على شدة الضوء وليس على تردده.

It predicts electrons should be emitted with any light.

تتوقع أن الإلكترونات يجب أن تنبعث عند سقوط أي نوع من الضوء.

It predicts a time delay for emission.

تتوقع وجود تأخير زمني قبل انبعاث الإلكترونات.



# QUANTUM THEORY AND THE ATOM

## Einstein's Explanation of the Photoelectric Effect:

part (particles)

Energy exists in the form of packets called photons, and the energy of a photon is given by:

الطاقة تكون على شكل كمّات (فوتونات)، وترتبط طاقة الفوتون بتردده حسب العلاقة:

$$E = hf$$

Electrons in a metal are bound with different energies.

To remove an electron, a minimum energy is required called:

ترتبط الإلكترونات في الفلز بقوى مختلفة، ولتحريرها يلزم حد أدنى من الطاقة يسمى:

Work function (W or  $\phi$ )

$$E \geq W \quad f \geq f_0$$

If the frequency of the incident light is less than the threshold frequency  $f_0$ :

$$f < f_0$$

إذا كان تردد الإشعاع الساقط أقل من تردد العتبة  $f_0$ :

➡ No electrons are emitted, no matter how strong the light is.

لا يحدث انبعاث للإلكترونات مهما زادت شدة الضوء.

Each photon interacts with one electron only.

كل فوتون يتفاعل مع إلكترون واحد فقط،

➡ Energy from multiple photons cannot combine to free one electron.

ولا يمكن تجميع طاقة عدة فوتونات لتحرير إلكترون واحد

If the photon frequency is greater than the threshold frequency:

$$f > f_0$$

➡ Part of the energy is used to release the electron

➡ The rest becomes kinetic energy of the electron:

$$KE = hf - W$$

or  $KE = E - W$

$$KE = hf - hf_0 = h(f - f_0)$$

◆ Where:

✓  $h = 6.626 \times 10^{-34} \text{ J} \cdot \text{s}$  (Planck's constant)

✓  $f$  = frequency of incident light

✓  $f_0$  = threshold frequency

✓  $W$  = work function

$$E \geq W$$

Work Function (W): minimum amount of energy required to liberate (release) electrons from its surface.

Threshold Frequency ( $f_0$ ): minimum frequency required to liberate (emit) an electron from the surface of a metal.

$$f \geq f_0$$



# QUANTUM THEORY AND THE ATOM

Increasing light intensity means more photons:

زيادة شدة الضوء تعني زيادة عدد الفوتونات:

➔ More emitted electrons

وبالتالي زيادة عدد الإلكترونات المنبعثة

➔ Higher electric current (if  $f \geq f_0$ )

أي زيادة التيار الكهربائي (بشرط أن  $f \geq f_0$ )

➔ **Important Note:**

In atomic physics, energy is often measured in electron volt (eV) instead of joules.

$$1 \text{ eV} = 1.6 \times 10^{-19} \text{ J}$$

⚡ **Photon Energy:**

$$E = hf = hc/\lambda$$



◆ **Using nanometers:**

$$E(\text{ev}) = 1240/\lambda(\text{nm})$$

**Important Note:**

1. Photon energy is delivered to only one electron at a time.
2. For each metal, there is a minimum energy needed to remove an electron (work function  $W$ ).
3. If  $hf < W$ :
  - No electrons are emitted.
4. If  $hf = W$ :
  - The electron is released with zero kinetic energy.
5. If  $hf > W$ :
  - The electron is released with kinetic energy:
 
$$KE = hf - W$$

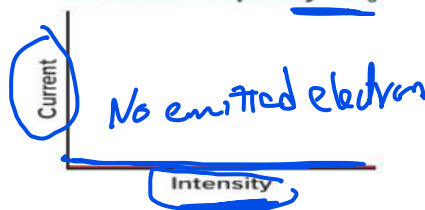
**From the Graph (Bottom Left): Relationships**

1. Increasing light frequency ( $f$ ) increases the maximum kinetic energy of the emitted electrons.
2. Increasing intensity increases the number of emitted electrons, not their energy.
3. Increasing work function ( $W$ ) decreases the kinetic energy of emitted electrons.

Current v. Frequency with Constant Intensity



Current v. Intensity with Constant Frequency  $< f_0$



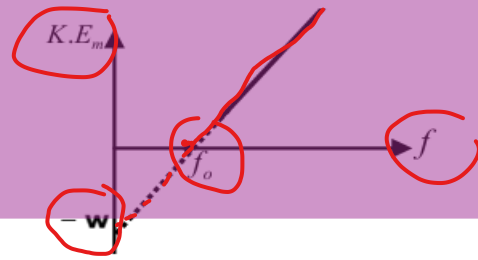
Current v. Intensity with Constant Frequency  $\geq f_0$



# QUANTUM THEORY AND THE ATOM

The graphical representation of  $K.E_m$  versus the frequency of the incident light ( $f$ ).

$$\text{Slope} = \frac{\Delta K.E_m}{\Delta f} = h = 6.63 \times 10^{-34} \text{ J/Hz}$$



The figure shows the relationship between the maximum kinetic energy of electrons emitted from a metal surface and the frequency of the incident light. Based on it, answer the following:

1 What does point (d) represent?

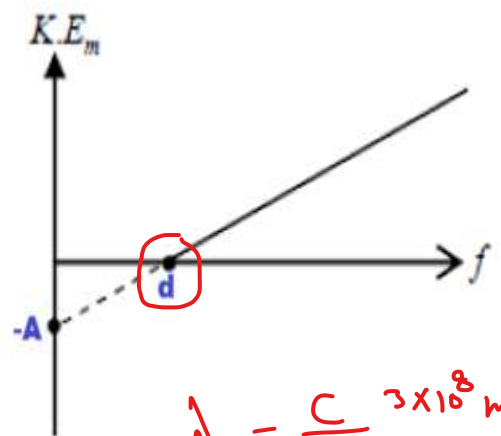
$f_0$

2 What does the slope of the graph represent?

$h$

3 What does point (a) represent?

$w$



$$\lambda = \frac{c}{f} = 3 \times 10^8 \text{ m/s}$$

4 What happens to the value of point (d) when the frequency of the incident light on the metal surface increases? Why? It does not change, because the value of (a) depends only on the type of metal

The graph shows the straight-line relationship between the maximum kinetic energy of the emitted electrons from a certain metal surface and the frequency of the incident light.

Based on the graph, answer the following:

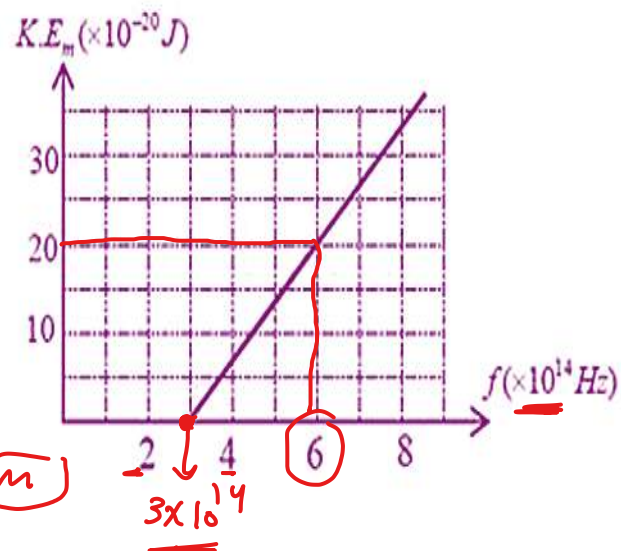
1) What is the threshold frequency of the metal?

$3 \times 10^4 \text{ Hz}$

2) What is the wavelength of the incident light that causes the emission of electrons with

$$KE = 20 \times 10^{-20} \text{ J} ?$$

$$\lambda = \frac{c}{f} = \frac{3 \times 10^8}{6 \times 10^{14}} = m$$



# QUANTUM THEORY AND THE ATOM

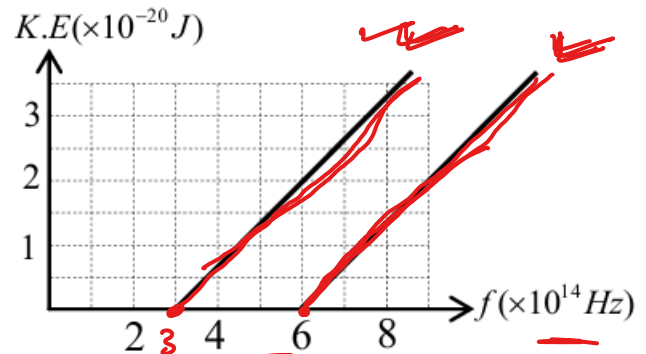
If the metal is replaced with another metal whose threshold frequency is twice that of the previous metal, draw on the same graph the linear relationship between the maximum kinetic energy of the emitted electrons and the frequency of the incident light. Also, state what happens to the slope of the line and justify your answer.

إذا استبدل المعدن بمعدن آخر تردده العتبي ضعف تردد المعدن السابق، ارسم على نفس الرسم البياني العلاقة الخطية بين الطاقة الحركية القصوى للإلكترونات المنبعثة وتردد الضوء الساقط. وضح أيضاً ما يحدث لميل الخط، وبرر إجابتك. جد الطول الموجي للتردد الجديد

$$f_0 = 3 \times 10^{14} \text{ Hz}$$

- From the graph, when  $K.E = 20 \times 10^{-20} \text{ J}$ , then  $f = 6 \times 10^{14} \text{ Hz}$

$$\lambda = \frac{c}{f} = \frac{3 \times 10^8}{6 \times 10^{14}} = 5 \times 10^{-7} \text{ m}$$



- The slope of the line does not change because it has a constant value (Planck's constant).

Condition	Energy Condition	Frequency Condition	Result
1	$E < W$	$f < f_0$	Electrons will never be emitted
2	$E = W$	$f = f_0$	Electrons are emitted <u>without</u> kinetic energy
3	$E > W$	$f > f_0$	Electrons are emitted with <u>maximum</u> kinetic energy

$$E = hf = h \frac{c}{\lambda}$$

(E) depends on (f) or ( $\lambda$ ) [frequency or wavelength]

(W) and ( $f_0$ ) depend only on the type of metal

(K.E<sub>m</sub>) depends on:

- $E \rightarrow$  Increasing E increases K.E<sub>m</sub>
- $W \rightarrow$  Increasing W decreases K.E<sub>m</sub>

$$K.E_m \propto (f - f_0)$$

inverse

$$K.E = 50 - 30 = 20$$

$$\downarrow K.E = 50 - 30 = 20$$

$$\sim 50 - 50 = 0$$



# QUANTUM THEORY AND THE ATOM

The graph shows the relationship between the maximum kinetic energy of electrons emitted from three metals and the frequency of the incident light. Based on the graph, answer the following:

1. What does point **(d)** represent on the **graph**?

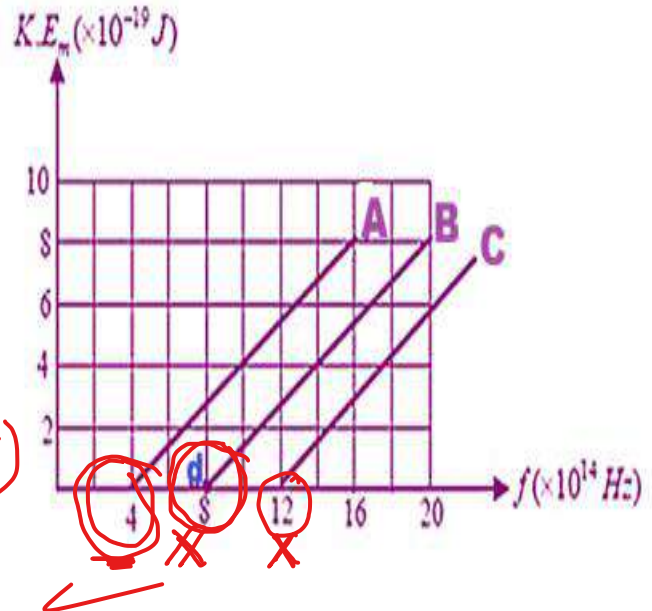
ماذا تمثل النقطة (d) على الرسم البياني؟

$$f_0 = 8 \times 10^{14} \text{ Hz} \rightarrow \text{metal (B)}$$

2. Calculate the work function of metal **(B)**.

احسب دالة الشغل للفلز (B).

$$W = h f_0 = 6.63 \times 10^{-34} \times 8 \times 10^{14} = \text{(J)}$$



3. If light with a frequency of  $7 \times 10^{14}$  Hz is incident, what is the maximum kinetic energy of the emitted electrons from each metal?

إذا سقط ضوء تردده  $7 \times 10^{14}$  هيرتز، فما هي الطاقة الحركية القصوى للإلكترونات المنبعثة من كل فلز؟

$$K.E_m = hf - hf_0 = 6.63 \times 10^{-34} [7 \times 10^{14} - 4 \times 10^{14}] = \text{(J)}$$

4. If light of a certain frequency causes electrons to be emitted from all three metals, which metal's electrons have the greatest kinetic energy?

إذا تسبب ضوء بتردد معين في انبعاث إلكترونات من الفلزات الثلاثة، فأى فلز تكون إلكتروناته ذات طاقة حركية أكبر؟

$$f_0 = 4 \times 10^{14} \rightarrow A$$

$$K.E \propto (f - f_0)$$

big ← inverse → small

5. What is the minimum frequency required to release electrons from all the metals **(A, B, and C)**?

$$f_0 = 12 \times 10^{14} \text{ Hz}$$

