Kurdistan Regional Government Iraq
Ministry of Higher Education & Scientific Research
Salahaddin University –Erbil
College of Basic Education
Department : General Science

Module : Semiconductor
Stage : second
Round:
Time : 90 min

Exams
2023-2024

Q1: A- Explain this statement (addition of energy creates change of state of matter). (8+8) Mark
B- Compare between covalent and ionic bonds.

Q2: A- Calculate the orbital radius of electron in hydrogen atom when energy (6+8) Marks

of electron is 0.3777 eV

B-Semiconductor energy bands at room temperature (creating free electron–hole pairs)

Q3 - Choose the correct answer 10 Marks

1- There are zero band gap in (A- Insulator B- Semiconductor C-Conductor) ,
2- Semiconductor a solid in which the highest occupied energy band is
(-energy gap B-valance band C-conduction band).
3- Conductivity of conductor increase by (A- decreasing temperature B-increasing temperature
C-Intendent on temperature)
4- This value 10^{-14} $\frac{S}{cm}$ is conductivity of

A- Conductor) , B= Semiconductor) C-Insulator

Q4 A Calculate energy gap of semiconductor material Marks

at $Temperture = 600\ k$ germanium By using this table

	Germanium	Silicon	GaAs
$E_g(0)$ (eV)	0.7437	1.166	1.519
α (meV/K)	0.477	0.473	0.541
β (K)	235	636	204

Best wishes Lecture\ Instructor: Dr Abbas H Rostam

Signature

Date :3 /4/ 2024

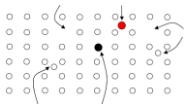
Kurdistan Regional Government Iraq
Ministry of Higher Education & Scientific Research
Salahaddin University –Erbil
College of Basic Education
Department : General Science

Module : Semiconductor
Stage : second
Round:
Time : 2 hours

Exams
2020-2021

Q1 A--Compare between Fermion and Bosons. (6+6) Marks

B- In below figure write the name of the defects in crystal



Q2- Choose the correct answer 12 Marks

1- Particles which are vibrating about a fixed position is called (A- Liquid B-Gas C-Solid).
2- Weakest bond is (A--Covalent B-Ionic C- metallic) bonds .
3- Highest occupied band in semiconductor (A-Valance band B-energy gap C-conduction band)
4- atomic sites where the original species has been replaced by anther host atoms is called (A-antisites B-Interstitial C-line defect)
5- both electrons and holes-absorb radiation without becoming excited into the other band, but makes a transition to another state in the same band this process is called (A- Exciton B- Free-carrier C- Direct band gap) absorption).
6- pair of cation and anion vacancies) in an ionic crystal is called (A- Schottky B- Frenkel C- Native point) defect. .

Q3-- A Calculate energy gap of semiconductor material (5+5+4) Marks

at $Temperture = 600\,k$ germanium By using this table

	Germanium	Silicon	GaAs
$E_g(0)$ (eV)	0.7437	1.166	1.519
α (meV/K)	0.477	0.473	0.541
β (K)	235	636	204

B- Calculate the number of Frenkel defects per cubic meter in zinc oxide at 1000˚C. The energy for defect formation is 3.5 eV, the number of lattice sites per cubic meter is $5 \times 10^{28}\ \frac{sites}{m^3}$ and Boltzmann constant $8.62 \times 10^{-5}\ \frac{eV}{K}$

C- Figure : Resistivity versus temperature for a typical conductor and semiconductor.

Q5 - A- Explain diffusion current density of electron in semiconductors (5+5) Marks

B- Explain creating free electron–hole pairs

Q4 - A- Explain Absorption processes involving impurities (8+6) Marks

B- Draw the direct and indirect band gap absorption

Best wishes Lecture\ Instructor : Dr Abbas H Rostam

Signature Date : 22-5-2021

Kurdistan Regional Government Iraq
Ministry of Higher Education & Scientific Research
Salahaddin University –Erbil
College of Basic Education
Department : General Science

Module : Semiconductor
Stage : second
Round:
Time : 1.30 hours

Exams
2020-2021

Q1 A- Compare between solid and liquid **(4 ,6) Marks**
B- po.

Q2: A- Explain mechanism of electron diffusion current density in semiconductor briefly.
defects

	Germanium	Silicon	GaAs
$E_g(0)$ (eV)	0.7437	1.166	1.519
α (meV/K)	0.477	0.473	0.541
β (K)	235	636	204

this table

Q5 - Choose the correct answer

1- particles which have integer spin is [A- electron B-photon c-proton]
2- energy gap of conductor is [A-1 eV B-zero C-4 eV]

3-

Q6- A- Draw the diagram of the point defects.

B- Compare between Direct and Indirect Semiconductors

Best wishes **Lecture\ Instructor : Dr Abbas H Rostam**
Singnature

Date : 10-4-2021

Kurdistan Regional Government Iraq
Ministry of Higher Education & Scientific Research
Salahaddin University –Erbil
College of Basic Education
Department : General Science

Module : Semiconductor
Stage : second
Round:
Time : 90 min

Exams
2020-2021

Q1- Complete the following statements **10 Marks**

1- States of matter based upon these -------- ,---------- , ----------
2- A plasma is ---------- of electricity and is affected by ----------.
3- As radius of electron in its orbits increase the velocity of electron ---------- .
4- Energy and radius of electron in hydrogen atom is -------- eV and---------- Angstrom respectively.

Q3: Choose the correct answer

5- Energy gap in semiconductor decrease by

(A- decreasing temperature B-increasing temperature C- constant])

1- The distribution of a fixed amount of particle among a number of energy bands depends
[A- energy gap and temperature B-density state and distribution function C- Density state and energy gap].
2- Photon is [A- boson with half spin B- fermion with integer spin C- boson with integer spin]
3- Below Fermi energy at absolute zero temperature all state
[A- empty from electron B-full from electron C- partially consist from electron].
4- If N_C greater than N_V intrinsic Fermi level position or (E_{Fi}) is
[A- below mid gap B- above mid gap C-at mid gap].
5- As temperature increase above zero kelvin probability distribution of electron below fermi
[A- empty decrease B- empty increase C-full increase].
6- Liquids have an [A- indefinite shape and a indefinite volume B- indefinite shape and a definite volume C- definite shape and a indefinite volume].

Q2- Explain P type semiconductor **6- Marks**

. **Best wishes** **Lecture\ Instructor: Dr Abbas H Rostam**

Singnature

Date : 18-4-2021

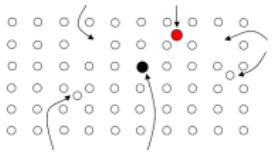
Kurdistan Regional Government Iraq
Ministry of Higher Education & Scientific Research
Salahaddin University –Erbil
College of Basic Education
Department : General Science

Module : Semiconductor
Stage : second
Round:
Time : 2 hours

Exams
2020-2021

Q1 A--Compare between Fermion and Bosons. (7+5) Marks

B- In below figure write the name of the defects in crystal



Q2- Choose the correct answer 12 Marks

1- Particles which are vibrating about a fixed position is called (A- Liquid B-Gas C-Solid).

2- Weakest bond is (A--Covalent B-Ionic C- metallic) bonds .

3- Highest occupied band in semiconductor (A-Valance band B-energy gap C-conduction band)

4- atomic sites where the original species has been replaced by anther host atoms is called (A-antisites B-Interstitial C-line defect)

5- both electrons and holes-absorb radiation without becoming excited into the other band, but makes a transition to another state in the same band this process is called (A- Exciton B- Free-carrier C- Direct band gap) absorption).

6- pair of cation and anion vacancies) in an ionic crystal is called (A- Schottky B- Frenkel C-Native point) defect.

Q3 A- Calculate the number of Frenkel defects per cubic meter in zinc oxide at 1000˚C. The energy fo defect formation is 3.5 eV, the number of lattice sites per cubic meter is $5 \times 10^{28}\ cm^{-3}$and Boltzmann constant $8.62 \times 10^{-5}\ eV/k$ (5+5+4) Marks

.

B- Calculate energy gap of semiconductor material $T = 600\ K$ germanium this table

	Germanium	Silicon	GaAs
$E_g(0)$ (eV)	0.7437	1.166	1.519
α (meV/K)	0.477	0.473	0.541
β (K)	235	636	204

C- Figure : Resistivity versus temperature for a typical conductor and semiconductor.

Q5 - A- Explain diffusion current density of electron in semiconductors (4+6) Marks

B- Explain creating free electron–hole pairs

Q4 - A- Explain Absorption processes involving impurities (8+6) Marks

B- Draw the direct and indirect band gap absorption

Best wishes Lecture\ Instructor : Dr Abbas H Rostam

Signature Date : 22-5-2021

Kurdistan Regional Government Iraq
Ministry of Higher Education & Scientific Research
Salahaddin University –Erbil
College of Basic Education
Department : General Science

Module : Semiconductor
Stage : second
Round: second semester
Time : 2 hours

Exams
2020-2021

Q1 A--Compare between Fermion and Bosons. (6+6) Marks
B-Draw diagram of typical point defects in crystal

Q2- Choose the correct answer 10 Marks

1- Particles which are vibrating about a fixed position is called (A- Liquid B-Gas C-Solid).
2- Weakest bond is (A--Covalent B-Ionic C- metallic) bonds .
3- atomic sites where the original species has been replaced by anther host atoms is called (A-antisites B-Interstitial C-line defect)
4- both electrons and holes-absorb radiation without becoming excited into the other band, but makes a transition to another state in the same band this process is called (A- Exciton B- Free-carrier C- Direct band gap) absorption).
5- pair of cation and anion vacancies) in an ionic crystal is called (A- Schottky B- Frenkel C-Native point) defect).

Q3 A- Calculate the number of Frenkel defects per cubic meter in zinc oxide at 1000˚C. The energy fo defect formation is 3.5 eV, the number of lattice sites per cubic meter is $5 \times 10^{28}\ cm^{-3}$and Boltzmann constant $8.62 \times 10^{-5}\ eV/k$ (5+5+4) Marks

.

B- Calculate energy gap of semiconductor material At $T = 600\ K$ for germanium by using this table

$E_{00g}(0)\ eV$	0.7437
$\alpha(meV/K)$	0.477
$\beta(K)$	235

C- Figure : Resistivity versus temperature for a typical conductor and semiconductor.

Q4 - A- Explain diffusion current density of electron in semiconductors (4+6) Marks

B- Explain creating free electron–hole pairs

Q5 - A- Explain Absorption processes involving impurities (8+6) Marks

B- Draw the direct and indirect band gap absorption

Best wishes Lecture\ Instructor: Dr Abbas H Rostam

Signature Date : 22-5-2021

Kurdistan Regional Government Iraq
Ministry of Higher Education & Scientific Research
Salahaddin University –Erbil
College of Basic Education
Department : General Science

Module : Semiconductor
Stage : second
Round: second semester
Time : 2 hours

Exams/ second trial
2020-2021

Q1 Answer only two branches

A- Compare between covalent and ionic bonds (6+6+6) Marks

B- Compare between direct and indirect band semiconductor.

C- Explain each addition of energy creates a change in state of matter.

Q2 A- Choose the correct answer 20 Marks

1- The important optical lattice properties: in which that ionic crystals exhibit strong absorption and reflection in region (A-Visible B-infrared C-UV)

2- Free-carrier absorption takes place even when at (A- $hf < E_g$ B-$hf > E_g$ C-$hf = E_g$).

3- Material have a definite shape and a definite volume is called (A- gas B-liquid **C**-solid).

4- In conductor energy gap is (A- 1 B- Zero C- 4) Ev.

5- When $N_C > N_V$ intrinsic fermi level position is at (A- in mid gap B- above mid gap C-below mid gap).

6- If electron in the fourth orbital number of the electron in the subshell is (A- 14 B- 16 C- 32).

7- Forbidden band is (A- Valance band B- Conduction band C- Energy gap).

8- $E_C(k) = E_C + \frac{\hbar^2 k^2}{2m_e}$ is (A- the energy of the valance band B- the energy of the conduction band C- the energy in the gap).

9- Edge dislocation is (A-Line B-Surface C-Volume) defects).

10- The material with resistivity decrease with increasing temperature is called (A-Insulator B- Semiconductor C-Conductor).

Q3 A- Draw relation between resistivity and conductivity for all types material. (6+6 +6) Marks

B- Explain native defects

C- Explain N type semiconductor.

Q4 – Notes: Answer only **(A or B) with C.**

A- Explain drift current density of electron in semiconductors (4+4+6) Marks

B-If energy gap of one semiconductor $1.4\ eV$ and $E_d = 0.15\ eV$, $E_a = 0.25$ eV

Determine energy of the photon in this case.

C- If electron in hydrogen atom translation from six orbitals to two orbital determine energy of photon or emission energy.

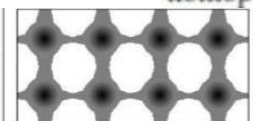
Best wishes Lecture\ Instructor: Dr Abbas H Rostam

Signature Date : / / 2021

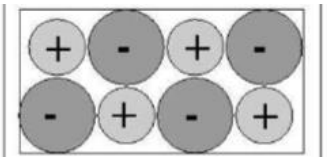
Answer of semiconductor examination / second stage /second trial: 2020-2021

Q1 A

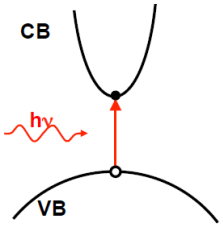
Solids	*Type of bond*	*Formation*	*Binding energy (eV/atom)*	*Typical examples*
1. Covalent	Covalent, atomic or homopolar bonds	Electron shared between two atoms	2–6	Carbon(diamond) Ge, Si, SiC, BN etc.

Covalent		Strong: ≤11 eV (molecules) ≤8 eV (solids)	C (graphite, diamond), Si

Solids	*Type of bond*	*Formation*	*Binding energy (eV/atom)*	*Typical examples*

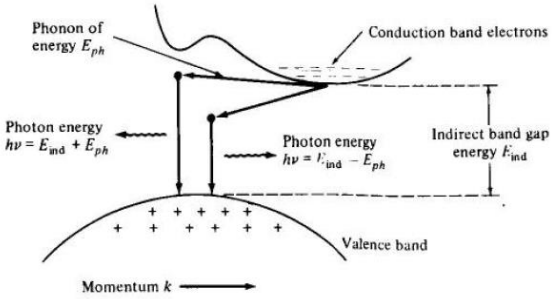
Ionic		Strong: ≤8 eV	NaCl; NaBr, KI

Direct semiconductor



Direct bandgap materials
- **CB minimum and VB maximum occur at the same k**
- **Examples**
  - **GaAs, InP, InGaAsP**
  - **$(Al_xGa_{1-x})As$, x < 0.45**

indirect band semiconductor

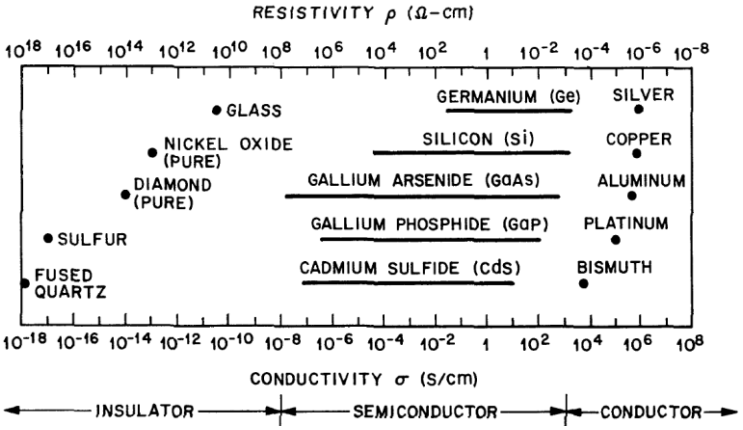


Indirect band gap CB minimum and VB maximum occur at different for example Si and Ge

Q2 Choose the correct answer

1- B-infrared **2- A-** $hf < E_g$ **3- C**-solid **4- B**- Zero
5- B- above mid gap **6-** A- 14 **7-** C- Energy gap
8- B- the energy of the conduction band **9-** A-Line **10- B Semiconductor**

Q3 A-

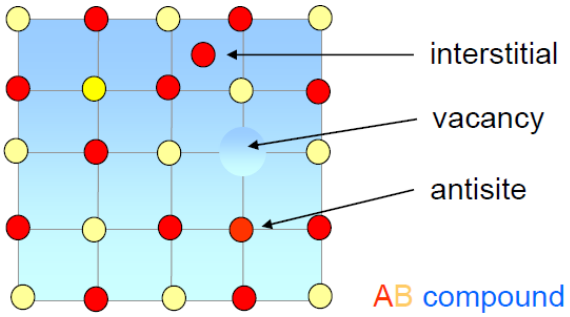


Q3 B Native point defects

Native defects are point defects due to atomic imperfections in the material. There are three types of native defects: vacancies, interstitials, and antisites. Vacancies are atomic sites where a host atom in an ideal crystal structure is missing shown Figure below

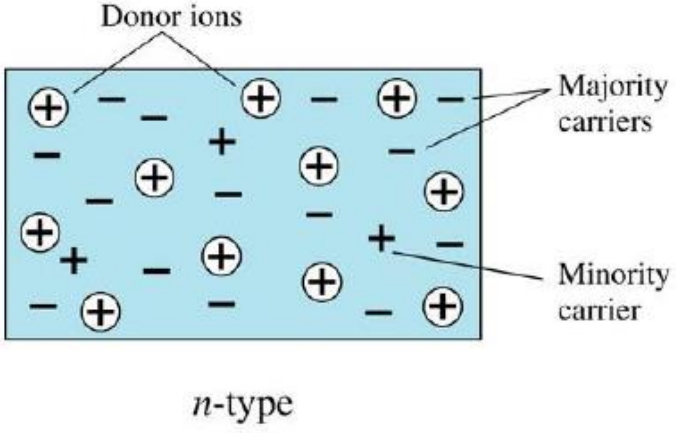
Antisite are atomic sites where the original atomic species has been replaced by another host atom in the crystal figure below.

Native defects are thermodynamically equilibrium defects. They are always present in every material at any temperature above absolute zero with varying concentrations. In general, the native defect concentration increases with increase in growth temperature



Q3 C

- **Add atoms with 5 valence-band electrons to intrinsic semiconductor**
- **ex. Phosphorous (P)**
- **"Donates" an extra e^- that can freely travel around**
- **Leaves behind a positively charged nucleus (cannot move)**
- **Overall, the crystal is still electrically neutral**
- **Called "n-type" material (added negative carriers)**



Q4 A- $$h\nu = E_g - E_d - E_a.$$

$$h\nu = 1.4\ eV - 0.15\ eV - 0.25\ eV = 1.4\ eV - 0.4\ = 1\ eV$$

B- $E_{Ph} = -\frac{13.6}{6^2} - \left(-\frac{13.6}{2^2}\right) \text{eV} = -\frac{13.6}{36} + \frac{13.6}{4} = \frac{-13.6+122.4}{36} = \frac{108.8}{366} = 3.02222\ eV$