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UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, July 2020

Programme: B.Sc. Physics (H) | **Semester : IV**
Course Name: Elements of Modern Physics | **Max. Marks : 100**
Course Code: PHYS 2005 | **Attempt Duration : 3 Hrs.**
No. of page/s: 21

Note:

1. Read the instruction carefully before attempting.
2. This question paper has two section, Section A and Section B.
3. There are total of six questions in this question paper. **One** in **Section A** and **six** in **Section B**
4. **Section A** consist of multiple choice based questions and has the total weightage of 60%.
5. **Section A** will be conducted online on BB Collaborate platform
6. **Section B** consist of long answer based questions and has the total weightage of 40%. The questions for section B shall also appear in BB Collaborate
7. **Section B** is to be submitted within 24 hrs from the scheduled time i.e. if the examination starts at 10:00 AM, the long answers must be submitted by 09:59:59 AM next day. Similarly, if the examination starts at 2:00 PM it must be submitted by 01:59:59 PM next day. (*Exceptional provision due extraordinary circumstance due to COVID-19 and due to internet connectivity issues in the far-flung areas*).
8. No submission of **Section B** shall be entertained after 24 Hrs.
9. **Section B** should be attempted after **Section A**
10. **Section B** should be attempted on blank white sheets (hand written) with all the details like programme, semester, course name, course code, name of the student, Sap id at the top (as in the format) and signature at the bottom (right hand side bottom corner)
11. Both section A & B should have questions from entire syllabus.
12. The COs mapping, internal choices within a section is same as earlier

Section – A (Attempt all the questions)

(60 marks. Please write how marks have been distributed)

1. **MCQs**

QUESTION 1 0.8 points Save Answer

CO3

Heavy nuclei have

- ○ more neutrons than protons
- ○ equal number of protons and neutrons
- ○ more electrons than neutrons
- ○ more protons than neutrons

Active Goals

Actions	ID	Goal	Goal Set Name	Category

Actions	ID	Goal	Goal Set Name	Category
	CO3	CO3	Course Goals	Course Objectives

QUESTION 2 3 points Save Answer

CO3

A beryllium-8 atom at rest undergoes double alpha decay as follows

$$^{8}_{4}\mathrm{Be} \rightarrow {}^{4}_{2}\mathrm{He} + {}^{4}_{2}\mathrm{He}$$

The atomic masses are:

$^{4}_{2}\mathrm{He}$	4.002603
$^{8}_{4}\mathrm{Be}$	8.005305

The kinetic energy of each departing α-particle, in keV, is closest to

- ○ 130
- ○ 65
- ○ 46
- ○ 92

Active Goals

Actions	ID	Goal	Goal Set Name	Category
	CO3	CO3	Course Goals	Course Objectives

QUESTION 3 1.8 points Save Answer

CO2

Which of the following is/are a truth about quantum mechanics? (Select all that apply)

- ☐ An electron can seem to interfere with itself when passing through double slits
- ☐

The total probability of finding the particle in space must be unity.

☐ Energy is quantized.

☐ A particle has a chance to be found in a region which should classically be impossible for it to be found in.

Active Goals

Actions	ID	Goal	Goal Set Name	Category
	CO2	CO2	Course Goals	Course Objectives

QUESTION 4 1.8 points Save Answer

CO1

Which among the following is (/are) true in case of Photo-electric effect? (Select all that apply)

☐ It is an instantaneous process

☐ The extinction voltage always remains constant with increase in intensity for a given frequency of light.

☐ The kinetic energy of photo-electron does not change with increase in intensity of incident radiation

☐ The work function of a given metal increases with increase in frequency of incident radiation

Active Goals

Actions	ID	Goal	Goal Set Name	Category
	CO1	CO1	Course Goals	Course Objectives

QUESTION 5 0.8 points Save Answer

CO3

If a C-14 has a half-life of 5730 years, then how long will it take for the number of C-14 atoms in a sample to drop to 1/8 of initial quantity?

○ 2.58×10^4 years

○ 1.72×10^4 years

○ 1.44×10^4 years

○ 2.29×10^4 years

Active Goals

Actions	ID	Goal	Goal Set Name	Category
	CO3	CO3	Course Goals	Course Objectives

QUESTION 6 0.8 points Save Answer

CO3

The radiations that can ionize the matter are

- alpha radiations
- beta radiations
- gamma radiations
- all of the above

Active Goals

Actions	ID	Goal	Goal Set Name	Category
	CO3	CO3	Course Goals	Course Objectives

QUESTION 7 0.8 points Save Answer

CO1

The dimensions of the quantity $\frac{h}{mc^2}$ is equivalent to those of

- Length
- Momentum
- Energy
- Time

Active Goals

Actions	ID	Goal	Goal Set Name	Category
	CO1	CO1	Course Goals	Course Objectives

QUESTION 8 0.6 points Save Answer

CO1

The concept of matter wave was suggested by_____.

- Laplace
- de Broglie
- Heisenberg
- Schrodinger

Active Goals

Actions	ID	Goal	Goal Set Name	Category
	CO1	CO1	Course Goals	Course Objectives

QUESTION 9 1.8 points Save Answer

CO4

Which of these is/are true statements? (Select all that apply)

- [ ] Population inversion is not a necessary condition to produce Laser.
- [ ] Absorption is always stimulated
- [ ] Spontaneous emission is always accompanied by stimulated emission.
- [ ] Example of optical pumping is Ruby Laser.

Active Goals

Actions	ID	Goal	Goal Set Name	Category
	CO4	CO4	Course Goals	Course Objectives

QUESTION 10 0.6 points Save Answer

CO2

For a particle inside an infinite potential box of width L, the potential is maximum when x equals to

$\frac{L}{2}$

L

$\frac{L}{4}$

$\frac{3L}{4}$

Active Goals

Actions	ID	Goal	Goal Set Name	Category
	CO2	CO2	Course Goals	Course Objectives

QUESTION 11 0.8 points Save Answer

CO4

Which of these is a property of Lasers?

- Monochromatic
- Directional
- Coherent
- All of the above

Active Goals

Actions	ID	Goal	Goal Set Name	Category
	CO4	CO4	Course Goals	Course Objectives

QUESTION 12 0.8 points Save Answer

CO4

The photons emitted by stimulated emission

- have the same phase as that of the incident radiation.

travel in the same direction as that of the incident photon.

have the same wavelength as that of the incident photon.

All of the above

Active Goals

Actions	ID	Goal	Goal Set Name	Category
	CO4	CO4	Course Goals	Course Objectives

QUESTION 13 0.8 points Save Answer

CO1

The Compton shift $\Delta\lambda$ is twice the Compton wavelength if the scattering angle is

90^o

45^o

180^o

0^o

Active Goals

Actions	ID	Goal	Goal Set Name	Category
	CO1	CO1	Course Goals	Course Objectives

QUESTION 14 3 points Save Answer

CO3

Find the number of alpha-decays that occur in a 1 gm sample of Thorium-232 in one year, if the disintegration constant of Thorium-232 is $1.58 \times 10^{-18}\ s^{-1}$?

12.98×10^{10}

36.75×10^{10}

1.298×10^{10}

○ 3.675×10^{10}

Active Goals

Actions	ID	Goal	Goal Set Name	Category
	CO3	CO3	Course Goals	Course Objectives

QUESTION 15 0.8 points Save Answer

CO3

Isotones are those which have

○ Same number of neutrons

○ Same number of protons

○ Same number of electrons

○ Same atomic number

Active Goals

Actions	ID	Goal	Goal Set Name	Category
	CO3	CO3	Course Goals	Course Objectives

QUESTION 16 1.8 points Save Answer

CO4

The dimension of the ratio of the probabilities of spontaneous and stimulated emission is

○ $M^{-2}L^{2}T^{-1}$

○ $M^{2}L^{-2}T$

○ $M^{-2}L^{2}T^{-2}$

○ $M^{2}L^{2}T^{-1}$

Active Goals

Actions	ID	Goal	Goal Set Name	Category
	CO4	CO4	Course Goals	Course Objectives

QUESTION 17 3 points Save Answer

CO1

Find the condition at which de Broglie wavelength equals the Compton wavelength.

- v = 0.7 c
- v = c
- v = 0.5 c
- v = 0.2 c

Active Goals

Actions	ID	Goal	Goal Set Name	Category
	CO1	CO1	Course Goals	Course Objectives

QUESTION 18 0.8 points Save Answer

CO2

The total probability of finding the particle in space must be

- zero
- 2
- Unity
- Infinity

Active Goals

Actions	ID	Goal	Goal Set Name	Category
	CO2	CO2	Course Goals	Course Objectives

QUESTION 19 1.8 points Save Answer

CO2

In the two slit interference experiment we get the interference pattern when

- the slits were open alternatively.
- the experiment provides no means of determining through which slit photon passes.
- a detector is added to determine through which slit photon goes.
- half of the photons went through one slit and half through the other.

Active Goals

Actions	ID	Goal	Goal Set Name	Category
	CO2	CO2	Course Goals	Course Objectives

QUESTION 20 1.8 points Save Answer

CO3

Find the mistake in the below given thermonuclear reaction.

$$^{13}_{7}N \rightarrow {}^{13}_{6}C + {}^{0}_{+1}e + \nu$$

- Instead of neutrino there should be the emission of anti-neutrino.
- Instead of positron there should be the emission of electron.
- Instead of C (Z = 6, A = 13) there should be the emission of O (Z = 8, A = 14) along with an electron.
- No problem in the reaction.

Active Goals

Actions	ID	Goal	Goal Set Name	Category
	CO3	CO3	Course Goals	Course Objectives

QUESTION 21 1.8 points Save Answer

CO2

Which of the following is/are the properties of a wave function? (Select all that apply)

- ☐ It must be single valued.
- ☐ It must be normalizable.
- ☐ It should not be finite everywhere.
- ☐ It must be continuous and have a continuous first derivative everywhere.

Active Goals

Actions	ID	Goal	Goal Set Name	Category
	CO2	CO2	Course Goals	Course Objectives

QUESTION 22 1.8 points Save Answer

CO2

Suppose $\psi = e^{2x}$ is eigen function of operator $\frac{d^3}{dx^3}$ then the eigen value will be

- ○ $4e^{2x}$
- ○ $8e^{2x}$
- ○ 4
- ○ 8

Active Goals

Actions	ID	Goal	Goal Set Name	Category
	CO2	CO2	Course Goals	Course Objectives

QUESTION 23 0.8 points Save Answer

CO3

Gamma (γ) radiation are fast moving

○

electrons

- neutrons
- protons
- photons

Active Goals

Actions	ID	Goal	Goal Set Name	Category
	CO3	CO3	Course Goals	Course Objectives

QUESTION 24 0.8 points Save Answer

CO2

How does the probability of an electron tunneling through a potential barrier vary with the thickness of the barrier?

- it decreases inversely with barrier thickness.
- it is independent of the barrier thickness
- it decreases linearly with barrier thickness
- it decreases exponentially with barrier thickness

Active Goals

Actions	ID	Goal	Goal Set Name	Category
	CO2	CO2	Course Goals	Course Objectives

QUESTION 25 0.8 points Save Answer

CO2

The square of the magnitude of the wave function is called

- current density
- probability density
- zero point energy
- volume density

Active Goals

Actions	ID	Goal	Goal Set Name	Category
	CO2	CO2	Course Goals	Course Objectives

QUESTION 26 1.8 points Save Answer

CO3

The decay constant of a radioactive nuclide is $4.5 \times 10^{-3}\ s^{-1}$. The half-life of the nuclide, in minutes, is closest to:

- 3.6
- 6.4
- 2.5
- 6.7

Active Goals

Actions	ID	Goal	Goal Set Name	Category
	CO3	CO3	Course Goals	Course Objectives

QUESTION 27 3 points Save Answer

CO2

Find the expectation value of position of a particle having wave function $\psi = a^2x$ between $x = 0$ & 1, $\psi = 0$ elsewhere?

- $\frac{a^4}{3}$
- $\frac{a^3}{4}$
- $\frac{a^4}{4}$

○ $\frac{a^2}{3}$

Active Goals

Actions	ID	Goal	Goal Set Name	Category
	CO2	CO2	Course Goals	Course Objectives

QUESTION 28 1.8 points Save Answer

CO4

Find the intensity of laser beam of 40 mW and diameter 1.5 mm. Assume the intensity to be uniform through the beam.

○ 0.0375 m/W

○ 17.77×10^3 W/m^2

○ 26.6 W/m

○ 5.66×10^3 W/m^2

Active Goals

Actions	ID	Goal	Goal Set Name	Category
	CO4	CO4	Course Goals	Course Objectives

QUESTION 29 1.8 points Save Answer

CO3

What are the numbers of protons Z and neutrons N in the missing fragment of the following fission reaction?

$$ {}^{1}_{0}n + {}^{235}_{92}U \rightarrow \ ? + {}^{140}_{55}Cs + 4{}^{1}_{0}n $$

○ Z = 92 and N = 37

○ Z = 37 and N = 89

○ Z = 37 and N = 55

○ Z = 37 and N = 92

Active Goals

Actions	ID	Goal	Goal Set Name	Category
	CO3	CO3	Course Goals	Course Objectives

QUESTION 30 3 points Save Answer

CO3

Determine the stability of Cl (Z = 17, A = 36) with respect to alpha, beta-plus, and beta-minus. Do not consider the possibility of decay by electron capture. The following atomic masses are known:

$^{4}_{2}He$	4.002603
$^{32}_{15}P$	31.973907
$^{36}_{16}S$	35.967081
$^{36}_{17}Cl$	35.968307
$^{36}_{18}Ar$	35.967546

The Cl (Z = 17, A = 36) nuclide is:

○ subject to beta-plus decay only.

○ subject to alpha decay only.

○ subject to beta-plus or beta-minus decay, but not to alpha decay.

○ subject to beta-minus decay only.

Active Goals

Actions	ID	Goal	Goal Set Name	Category
	CO3	CO3	Course Goals	Course Objectives

QUESTION 31 3 points Save Answer

CO3

One of the fusion reactions that occur in the sun is

$$^{3}_{2}\mathrm{He} + ^{3}_{2}\mathrm{He} \rightarrow ^{4}_{2}\mathrm{He} + ^{1}_{1}\mathrm{H} + ^{1}_{1}\mathrm{H}$$

The following masses are known

The reaction energy, in MeV, is closest to

- 19
- 13
- 17
- 11

Active Goals

Actions	ID	Goal	Goal Set Name	Category
	CO3	CO3	Course Goals	Course Objectives

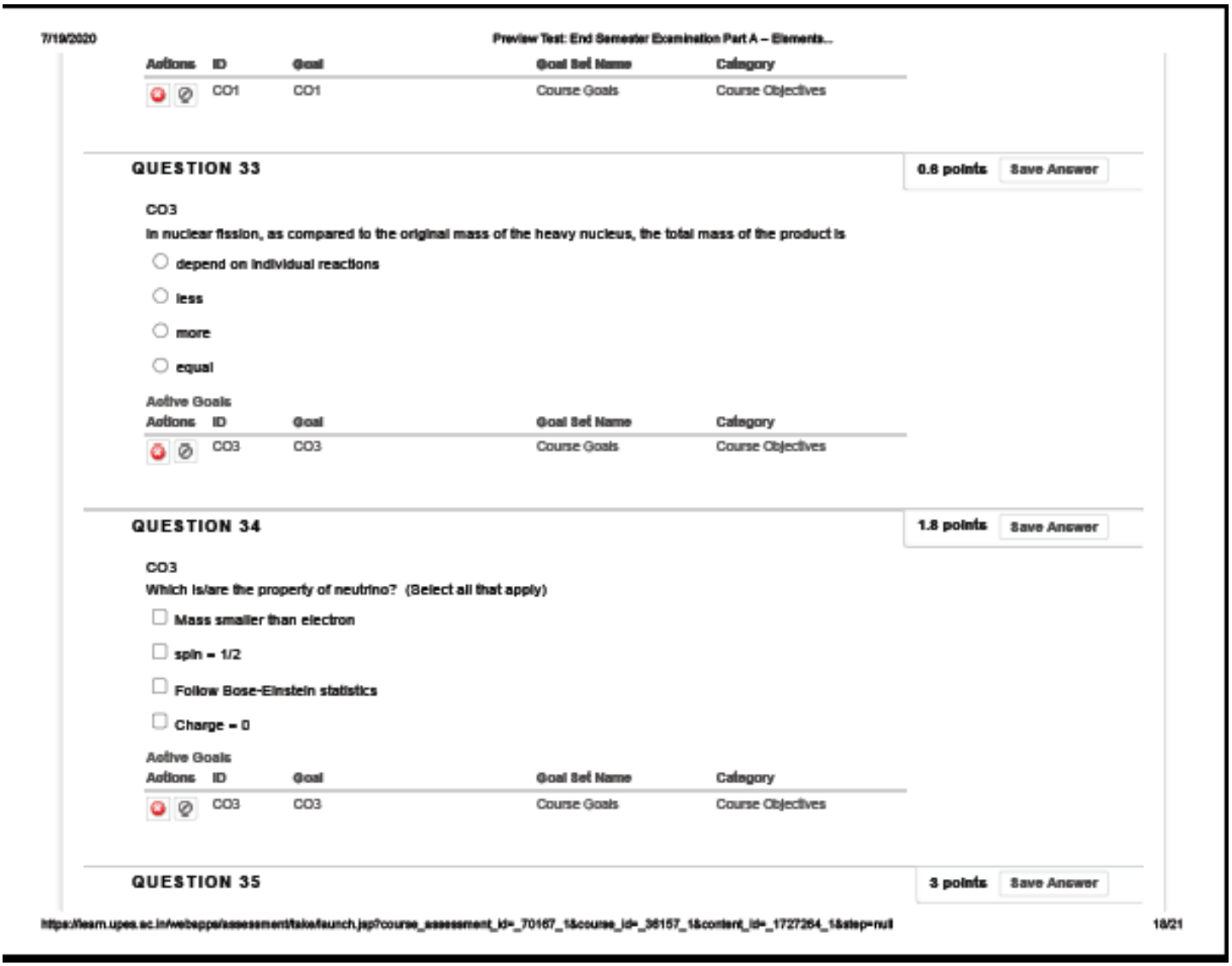
QUESTION 32 0.6 points Save Answer

CO1

Photons are electromagnetic radiation with _____rest mass and_____ charge.

- variable, zero
- zero, zero
- variable, negative
- zero, negative

Active Goals



7/19/2020 Preview Test: End Semester Examination Part A – Elements...

Actions	ID	Goal	Goal Set Name	Category
	CO1	CO1	Course Goals	Course Objectives

QUESTION 33 0.8 points Save Answer

CO3

In nuclear fission, as compared to the original mass of the heavy nucleus, the total mass of the product is

- depend on individual reactions
- less
- more
- equal

Active Goals

Actions	ID	Goal	Goal Set Name	Category
	CO3	CO3	Course Goals	Course Objectives

QUESTION 34 1.8 points Save Answer

CO3

Which is/are the property of neutrino? (Select all that apply)

- Mass smaller than electron
- spin = 1/2
- Follow Bose-Einstein statistics
- Charge = 0

Active Goals

Actions	ID	Goal	Goal Set Name	Category
	CO3	CO3	Course Goals	Course Objectives

QUESTION 35 3 points Save Answer

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CO2

An electron in an infinite potential well makes a transition from 3rd level to the ground state (lowest energy level) and in so doing emits a photon of wavelength 20.9 nm. What is the width of this well?

- 2 mm
- 0.21 nm
- 0.54 nm
- 0.89 nm

Active Goals

Actions	ID	Goal	Goal Set Name	Category
	CO2	CO2	Course Goals	Course Objectives

QUESTION 36

3 points Save Answer

CO2

A beam of 12 eV electrons is incident on a potential barrier of height 30 eV and width 0.05 nm. Calculate the transmission coefficient.

- 0.44
- 0.56
- 1.2
- 1

Active Goals

Actions	ID	Goal	Goal Set Name	Category
	CO2	CO2	Course Goals	Course Objectives

QUESTION 37

1.8 points Save Answer

CO3

The nuclear radius of Copper (Z = 29 and A = 64) is

- 9.6 fm
-

2.4 fm

4.8 fm

9.6 Å

Active Goals

Actions	ID	Goal	Goal Set Name	Category
	CO3	CO3	Course Goals	Course Objectives

QUESTION 38 0.8 points Save Answer

CO3

The rate of radioactive decay is proportional to

- number of unstable nuclei
- number of protons
- number of neutrons
- nature of rays

Active Goals

Actions	ID	Goal	Goal Set Name	Category
	CO3	CO3	Course Goals	Course Objectives

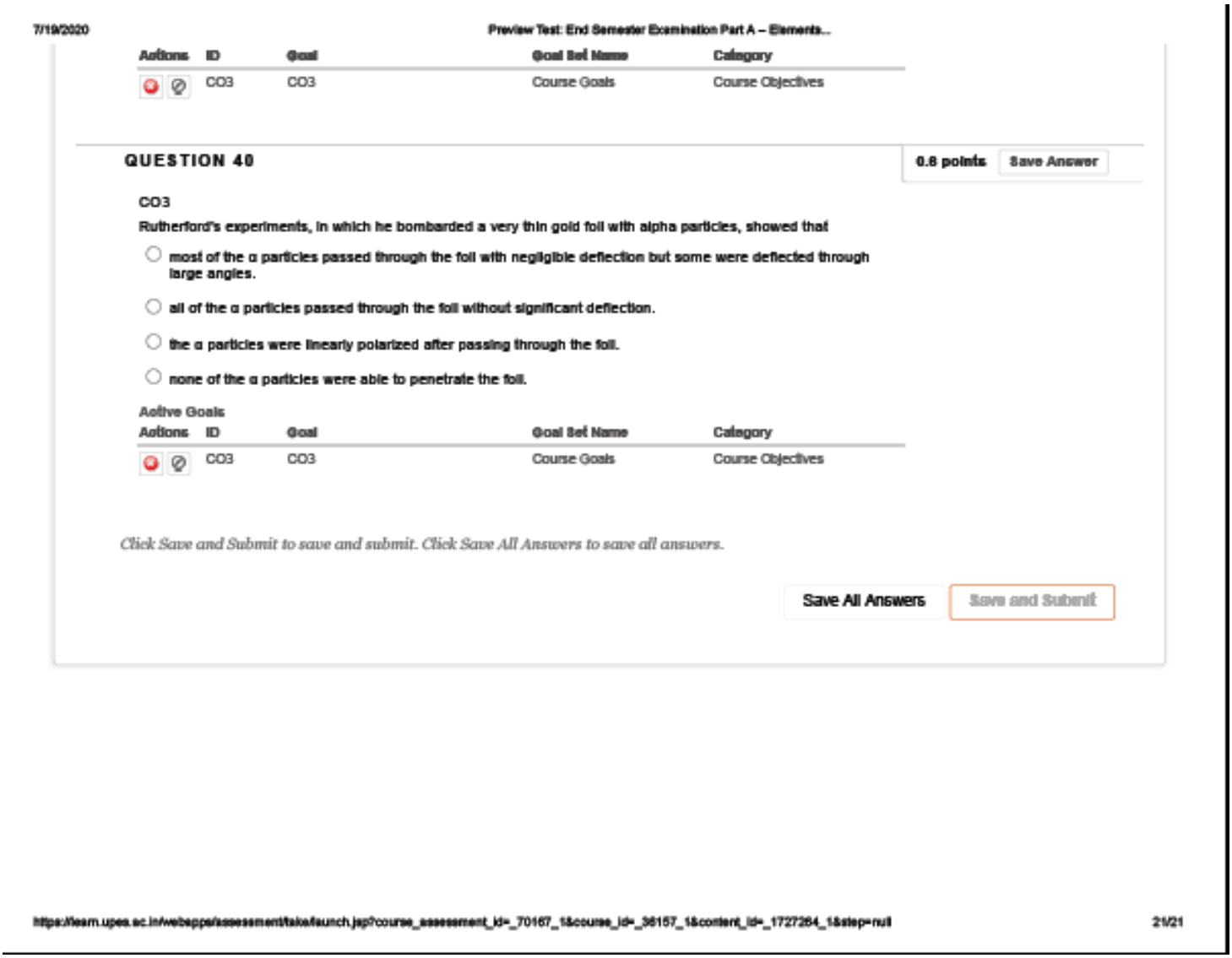
QUESTION 39 1.8 points Save Answer

CO3

Scandium Sc (Z = 21, A = 44) decays by emitting a positron. The nuclelde that is the product of the decay is

- Ti (Z = 22, A = 44)
- Sc (Z = 21, A = 43)
- Sc (Z = 21, A = 45)
- Ca (Z = 20, A = 44)

Active Goals



7/19/2020 Preview Test: End Semester Examination Part A – Elements...

Actions	ID	Goal	Goal Set Name	Category
	CO3	CO3	Course Goals	Course Objectives

QUESTION 40 0.8 points Save Answer

CO3

Rutherford's experiments, in which he bombarded a very thin gold foil with alpha particles, showed that

- most of the α particles passed through the foil with negligible deflection but some were deflected through large angles.
- all of the α particles passed through the foil without significant deflection.
- the α particles were linearly polarized after passing through the foil.
- none of the α particles were able to penetrate the foil.

Active Goals

Actions	ID	Goal	Goal Set Name	Category
	CO3	CO3	Course Goals	Course Objectives

Click Save and Submit to save and submit. Click Save All Answers to save all answers.

Save All Answers Save and Submit

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Section – B (Attempt all the questions)
(40 marks)

Q2	Starting from the momentum conservation equations (in Compton effect) derive a relation between the angle of scattering Ø and angle of recoil θ. $$tan\theta = \frac{cot\frac{\emptyset}{2}}{1+\frac{hv}{m_o c^2}}$$ where v is the frequency of incident photon and m_0 is the rest mass of the electron.	**6**	**CO1**

Q3	Find the Normalization constant N for the wave-function $$\varphi(x) = N\, e^{-\lvert x\rvert} sin\alpha x$$	**8**	**CO2**
Q4	A beam of electrons impinges on an energy step barrier of height 0.035eV. Calculate the fraction of electrons reflected and transmitted at the barrier when the energy of the electron is (i) 0.045eV (ii) 0.020eV	**6**	**CO2**
Q5	Write a note on the semi-empirical mass formula inclusive of all terms of binding energy.	**8**	**CO3**
Q6	A piece of an ancient wooden boat shows an activity of ^{14}C of 3.9 disintegrations per minute per gm of Carbon. Estimate the age of the boat if the half-life of ^{14}C is 5568 years. Assume that the activity of fresh ^{14}C is 15.6 dpm. gm.	**6**	**CO3**
Q7	Establish a relation between Einstein's A and B coefficients.	**6**	**CO4**

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