Title

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Contents

1 Question 1

How many isomorphism classes are there of groups of order 45?

Describe a representative from each class.

2 Question 2

Let R be a ring with the property that for every $a \in R, a^2 = a$.

(a) Prove that R has characteristic 2.

(b) Prove that R is commutative.

3 Question 3

Let $F = \mathbb{F}_p$, where p is a prime number.

(a) Show that if $\pi(x) \in F[x]$ is irreducible of degree d, then $\pi(x)$ divides $x^{p^d} - x$.

(b) Show that if $\pi(x) \in F[x]$ is an irreducible polynomial that divides $x^{p^n} - x$, then $\deg \pi(x)$ divides n.

4 Question 4

Let R be a commutative ring with 1.

Recall that $x \in R$ is nilpotent iff $xn = 0$ for some positive integer n.

(a) Show that every proper ideal of R is contained within a maximal ideal.

(b) Let $J(R)$ denote the intersection of all maximal ideals of R.

Show that $x \in J(R) \iff 1 + rx$ is a unit for all $r \in R$.

(c) Suppose now that R is finite. Show that in this case $J(R)$ consists precisely of the nilpotent elements in R.

5 Question 5

Let G be a group of order 105 and let P, Q, R be Sylow 3, 5, 7 subgroups respectively.

(a) Prove that at least one of Q and R is normal in G.

(b) Prove that G has a cyclic subgroup of order 35.

(c) Prove that both Q and R are normal in G.

(d) Prove that if P is normal in G then G is cyclic.